SCHOOL SCIENCE AND MATHEMATICS

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PRELIMINARY REPORT OF THE INTERNATIONAL COMMISSION ON SECONDARY MATHEMATICS.

A. INTRODUCTION.

The section *Philosophy, History and Instruction* of the Fourth International Congress of Mathematicians, held at Rome, April 6 to 11, 1908, listened to a series of reports on the teaching of mathematics in the principal countries. On the initiative of Professor David Eugene Smith, author of the report on the United States, the Section decided to submit to the Congress a resolution to create an international commission to make a general study of the progress of mathematical instruction among the various nations. This proposition had already been formulated by the learned New York professor, in 1905, in his reply to an inquiry of the International Review, *L'Enseignement Mathématique* (p. 469), on the "reforms to be accomplished.' The resolution was actively endorsed by the Congress, which, in the meeting of April 11, adopted the following resolution:

"The Congress recognizing the importance of a comparative examination of the methods and plans of study of the instruction in mathematics in the secondary schools of the different nations, empowers Messrs. Klein, Greenhill and Fehr to form an International Commission, which will study these questions and present a general report to the next Congress."

The next Congress will be held at Cambridge, England, in August, 1912.

The Committee was organized, as follows:

President: Professor F. Klein, Göttingen.

Vice-President: Professor Sir George Greenhill, London.

General Secretary: Professor H. Fehr, Geneva.

The Committee began work immediately, and at a meeting held at *Cologne*, September, 1908, adopted this preliminary report on the organization of the Commission and the general scope of its work.

B. ORGANIZATION OF THE COMMISSION.

I. The Delegations.

(a) The Commission is formed by delegates representing the countries which have taken part in at least two of the international Congresses of Mathematicians with an average of at least two members. Each of these countries is entitled to one delegate. Those countries which have had an average of at least ten members may have two or three delegates. In voting and in discussions of the Commission each country will have, however, but one vote.

These countries, called *participating countries,* which are invited to take part in the work of the Commission, are the following:

Germany (2 or 3 delegates).
Austria (2 or 3 delegates).
Belgium (1 delegate).
Denmark (1 delegate).
Spain (1 delegate).
Hungary (2 or 3 delegates).
Great Britain (2 or 3 delegates).
Italy (2 or 3 delegates).
Norway (1 delegate).
Portugal (1 delegate).
United States (2 or 3 delegates).
France (2 or 3 delegates).
Greece (1 delegate).
Holland (1 delegate).
Roumania (1 delegate).
Russia (2 or 3 delegates).
Sweden (1 delegate).
Switzerland (2 or 3 delegates).

(b) The countries which do not fulfill above conditions, but which by their institutions are able to contribute to progress of the science, are invited to be represented by a delegate who will follow the work of the Commission, without, however, taking part in voting.

These countries will be called *associated countries.* We present a first list which may be augmented.

Argentine Republic.
Australia.
Brazil.
China.
Cape Colonies.
Egypt.
India.
Bulgaria.
Canada.
Chili.
Mexico.
Peru.
Servia.
Turkey.
Japan.

(c) *National Sub-Commissions.*

The different delegations are invited to affiliate with themselves national sub-commissions, comprising representatives of the various stages of the teaching of mathematics in the general schools

and in the technical and professional schools. These sub-commissions are designed to aid the delegates in the elaboration of the reports which are discussed under sub-head G.

II. The Central Committee.

The Commission is under the direction of the committee of three members designated by the Fourth International Congress of Mathematicians. This is called the *Central Committee,* and has most extended powers. With the consent of the Commission it reserves to itself all rights concerning the organization and the publication of the general reports of the commission.

In regard to the constitution of the Commission, the committee desires the active support of those who are particularly interested in the progress of the teaching of mathematics. They would request such persons to inform their government of the movement so that the government shall have some knowledge of the aim and organization of the Commission when it shall be invited to approve the propositions of the committee in regard to the delegation, as well as for the propositions of the delegates in the matter of the national sub-commission. Because of the very great task which falls to the delegations, it is highly desirable that their work should begin as soon as possible.

III. Financial Matters.

As the Fourth International Congress did not furnish any funds, the governments of the *participating countries* are invited to place at the disposition of their delegation a sum sufficient to cover the expenses of the delegation and of the national sub-commission, and to contribute to the general expenses of the Commission.

To provide for the general expenses of the Commission (including notably expenses of the general secretary and of the Central Committee), a fund will be formed by each of the *participating* countries contributing 100 francs annually; this should be sent to the general secretary in early January of 1909, 1910, 1911 and 1912, or, if preferred, in one sum in 1909. The general secretary will present a financial report at the meeting of the Commission at Cambridge in 1912, on the occasion of the Fifth Congress.

The delegates of the *associated countries* are requested to communicate directly with their governments in regard to the expenses of the delegations. The committee reserves the right to fix later, if desirable, a slight participation of the associated countries in the general expenses.

C OFFICIAL ORGAN OF THE COMMISSION.

PUBLICATIONS OF THE REPORTS OF THE SUB-COMMISSIONS.

The international journal, *L'Enseignement Mathématique*, edited by Messrs. Laisant and Fehr, will be the organ of the Commission. This journal will publish the preliminary report and will announce the composition of the delegations. Subsequently it will report regularly the work of the Commission and of the sub-commissions.

It goes without saying that these communications may be reproduced by other journals or by other means of publication.

The sub-commissions will publish their reports according to their own convenience. The Central Committee expresses, however, the desire that these reports be printed in the same form as *L'Enseignement Mathématique*, and that the delegations should send 75 copies to the general secretary for distribution to the members of the Commission.

D. OFFICIAL LANGUAGES.

Correspondence and reports should be in one of the four languages admitted in the International Congress of Mathematicians, according to the wish of the authors. These languages are: German, English, French and Italian.

E. GENERAL AIM OF THE COMMISSION.

In conformity with the various opinions which were expressed at Rome, the Central Committee holds that the general aim of the Commission should be as follows:

To make an investigation and publish a general report on the actual tendencies of the teaching of mathematics in the various countries.

Regard should be paid not only to the methods of instruction and courses of studies, but also to the general scheme (organization) of studies, without, however, giving a complete historical development of the same. It is not the purpose of the Commission to elaborate statistics.

In every case the work of the Commission ought to make evident what are the general principles which should inspire the teacher, rather than to seek uniformity of details or to propose programs which should be adapted at the same time to the institutions of the various countries.

F. ORGANIZATION OF WORK.

In order that the study, of which we are giving the general

plan, should achieve results really useful to the progress of instruction, it is indispensable that all the delegates and their national sub-commissions collaborate actively and devotedly.

The delegations of the *participating countries* will be asked first and foremost to give their counsel on the general plan of the work; then, in the first place, they will make out their report with the aid of their sub-commissions, according to the plan of work that has been fixed by the Central Committee. For the *associated countries* this report is optional.

It is desirable that the principal points of the reports be previously discussed, in each country, at educational gatherings and in scientific societies, technical or others, which interest themselves in the progress of the teaching of mathematics. It would be well on the other hand to accompany the text with as precise and complete bibliographical notes as possible.

The printed reports should be sent to the general secretary at the beginning of 1911.

The Commission will meet in conference during the Easter vacation of 1911 to make a general study of the questions raised in the general program and to decide upon the fundamentals of the combined report. In regard to the editing of this, the Central Committee will study the necessary measures in order that it may be presented to the Congress in 1912, and will submit these measures to the Commission.

G. OBJECT OF THE WORK OF THE COMMISSION.

I. GENERAL CONSIDERATIONS.

The text of the resolution of the Congress at Rome mentions only the teaching of mathematics in secondary schools. But, as the aim of these schools and the length of their courses vary in different countries, the committee extends its work to include the whole field of mathematical instruction, from the earliest work to the higher instruction. It will not confine itself to the institutions leading to the university, but it will study also the teaching of mathematics in technical and professional schools. Because of the growing importance of these schools and of the new requirements which are continually demanded of mathematical instruction, it is necessary to accord in this inquiry a large place to applied mathematics.

The work of the Commission will be based upon the reports of the delegates of the *participating countries*, which are to be made out with the aid of the national sub-commissions in conformity with the general plan fixed by the Central Committee. In the

first part of these reports will be given a view of the *actual scheme* of studies, the corresponding examinations, the methods of teaching and the preparation of the teaching body. It is only after this exposition that one will be able to examine and present clearly what are the *actual tendencies* of the instruction, tendencies which show themselves often in the nature of the reforms accomplished in the course of the last few years. This will be the purpose of the *second part*, which includes the same divisions as the first.

II. GENERAL PLAN OF THE WORK.

First Part.

Actual State of the Organization and the Methods of Mathematical Instruction.

Section I. The Various Types of Schools.—In this first chapter will be given a *concise exposition* of the various public institutions of learning in which mathematical instruction is given and the aim of each school will be indicated. Schools for girls will be included.

The institutions will be distributed according to the following classification:

(a) Primary schools, lower and higher.

(b) Middle schools or higher secondary (lycées, German Gymnasiums and Realschulen, etc.).

(c) Middle professional schools (Technicum, etc.).

(d) Normal schools of the various grades (seminaries for teachers, "teachers' colleges," etc.).

(e) Higher institutions: Universities and Technical Schools.

It is desirable that this exposition be accompanied by a *schematic table* giving a general view and making evident the succession and correspondence between the diverse establishments and indicating also the average age of the students.

Section II. Aim of the Mathematical Instruction and of the Separate Branches.—This question will be studied for the various types of institutions mentioned above taking into account, wherever necessary, applied mathematics, notably mechanics.

Not only does *the aim of mathematical instruction* vary necessarily in different institutions, but it has undergone some transformations in the course of the last decade. It may be purely formal, or formal with regard to intuition; it may also tend to logical development and keep in view the utilitarian side, or else regard only

the practical. On the other hand, the development of the memory may be the principal aim, or contrariwise the development of the mathematical faculties.

What are the *branches of mathematics* taught in the different types of schools? The time allotted to the branches will be indicated and the extent of the program. To what extent is attention paid to correlation among the mathematical branches and, if there is occasion, the correlation between these branches and applied mathematics (including mechanics) and physics?

Section III. THE EXAMINATIONS.—It is incontestable that the system of examinations has a great influence on the method of instruction. The characteristics of the examinations in each category of schools will be summarily indicated, and particularly those which lead to "certificates of maturity," to "degrees," etc., and the examinations of candidates for teaching.

Section IV. THE METHODS OF TEACHING.—What are the methods used in the various institutions, from the primary schools up to the higher institutions? Material of instruction; mathematical models; use of manuals, text-books, collections of problems. Theoretical problems; problems taken from the applied sciences. Practical work.

Section V. PREPARATION OF CANDIDATES FOR TEACHING.—Here again are to be included the diverse types of schools, and there is to be indicated the requirements demanded by the school authorities: (a) with regard to theoretical preparation; (b) to professional preparation.

SECOND PART.

MODERN TENDENCIES OF THE TEACHING OF MATHEMATICS.

Section I. MODERN IDEAS CONCERNING SCHOOL ORGANIZATION.—Reforms in studies. New types of schools. The question of co-education of the two sexes.

Section II. MODERN TENDENCIES CONCERNING THE AIM OF INSTRUCTION AND OF THE BRANCHES OF STUDIES.

Aim of instruction.—New branches or new chapters to substitute for useless topics of study in the course, or those of secondary interest, but retained by pure tradition or by routine.

Considering the rapid progress of mathematics and its applications, the Committee proposes to examine anew with care what are the branches of this science most able to contribute to general culture. Among the subjects which demand actually a place in the elementary programs may be mentioned, on one hand, differential and integral calculus, analytical geometry, certain notions of descriptive and projective geometry, and a study of physics from the mathematical point of view.

On the other hand it is proposed to introduce new subjects, of a more special kind, or new fundamental notions (such as the notions of function, of groups, of sets). It will be useful for the investigation to examine in what measure account may be taken of these demands and that it establish what is the necessary minimum of the elements of Euclidean geometry, descriptive and projective geometry, algebra, differential and integral calculus, trigonometry and analytical geometry, to form a foundation for subsequent studies.

The same question arises for professional schools. What are the branches useful for the different careers?

Section III. EXAMINATIONS.—Projects of study for the transformation of the system of examinations or for their complete suppression.

Section IV. THE METHODS OF TEACHING.—Modern ideas concerning methods at different stages of instruction and in different types of schools. Correlation among mathematical branches. Relation between mathematics and other branches. Problems and practical applications; models and instruments. The use of manuals.

ON CERTAIN POINTS OF THIS CHAPTER. 1. Since the period of Pestalozzi, psychological considerations have played an important role in primary education, and, for a generation they have been useful, in a certain measure, in the formation of programs for secondary schools. It is in place to examine what are the results of psychology in the teaching of mathematics, and to what degree are they useful in the reform of this teaching. It is advisable to examine particularly the role of the initiatory instruction and the necessity of preceding theoretical instruction by intuitive instruction.

At what moment, on the contrary, should purely logical considerations take the preponderance, for example in the study of elementary geometry or in differential and integral calculus?

2. THE PRACTICAL APPLICATIONS.—Many schools have devoted long discussions to the part which should be assigned to considerations of practical and experimental nature.

(a) In elementary instruction may be mentioned, for example, paper folding, outdoor work, use of simple instruments of measuring, observational geometry, etc.; practical calculating and approximations (degree of approximation, logarithms to different numbers of places, use the slide-rule, etc.); the general question of graphics in algebra, the more extensive use of cross-section paper.

(b) The question of mathematical laboratories has been agitated during the last few years. What has been done in this matter and what are the results?—Mathematical models made by the pupils. The place of collections of models.

What are the means which will permit mathematics to be accorded a better place in the popular instruction (university extension)?—Place of applied mathematics in Museums.—Mathematical Recreations.

There is here a totality of natural means to react against the popular prejudices against mathematics.

3. CORRELATION AMONG THE DIFFERENT MATHEMATICAL BRANCHES.—It will be useful to examine in what measure may be made to disappear the conventional limits which exist between certain subjects of pure mathematics, such as algebra and geometry, algebra and differential and integral calculus, Euclidean and analytical geometry, and geometry and trigonometry. Not only the possibility of such reform should be investigated, but also regard should be paid to the inconveniences and the dangers which may result, which is all important.

It will be well, on the other hand, to know the result of the following transformations which have been proposed or re-examined during the last few years:

(a) The place of demonstrative geometry relative to algebra. (b) The fusion of plane and solid geometry. (c) The more intimate union of differential and integral calculus or the introduction of the latter before the former.

4. RELATIONS BETWEEN MATHEMATICS AND OTHER BRANCHES.—In the same connection, it will be useful to examine the points of contact which exist between mathematics and the other branches; thus the relations: (1) with drawing (geometrical, technical and artistic); (2) with the applied sciences; (3) with the other scientific branches (physics, chemistry, biology, geography, etc.); (4) with philosophy; (5) with the problems of daily life.

These points of contact are important for that which concerns practical education. It will not be sufficient to study simply the possibilities and the general desiderata, it is necessary to take account of that which has been successfully done and of the dangers involved. For example, those who desire a close relation between mathematics and physics ought to show exactly what geometrical notions have a direct bearing on physics, and to cite those problems of elementary physics which require simultaneous linear equations, equations of the second degree in one or more unknowns, irrational equations and progressions.

5. HISTORICAL CONSIDERATIONS.—Demand is being made that a larger place be accorded to the historical development of mathematics. In what degree is this possible and desirable?

Section V. THE PREPARATION OF TEACHERS.—What are the conditions which a rational preparation of candidates for teaching should fulfill? How are the theoretical courses and the practical preparation to be organized?

The progress of teaching depends directly on the preparation of the teachers. This is a question of fundamental importance. The studies and the exigencies vary necessarily from one country to another; they depend much on the number of candidates and the facilities at hand in regard to education. So the committee believes that it will be useful to take account of the reforms or the projects for reform which are actually being made with a view to securing the training of teachers conformably to modern

conditions, and that not only for the personnel of primary and secondary schools but also for the university.

This inquiry should touch notably:

(a) The mathematical work required of candidates.

(b) Their introduction to scientific research.

(c) The best method of presenting theoretical and practical pedagogy (considered as the science of education).

(d) The question of the sex of the teacher in different school years.

(e) Questions concerning, for example, the time to be devoted to the history of mathematics, the history of the teaching of mathematics, the recreational side of mathematics, and general literature touching mathematical education.

GENERAL REMARK.

In each of these sections it is to be emphasized *concisely*, on one hand that which characterizes the proposed reforms, and on the other hand what are the dangers to be avoided and the objections which are made by those who oppose the proposed changes. The following are some of the fundamental questions which ought to be discussed:

1.—The desire to render instruction attractive may detract from its serious character, a result which would be disastrous as much from the standpoint of the science as from the practical value of mathematics.

2. A misconceived psychology might lead to an exaggerated use of the logical bases of mathematics, with an attendant result on the pupil of continual uncertainty.

3. The fact of neglecting the abstract side which seems necessary to fix indelibly in the mind the fundamental mathematical truths.

4. Taking account only of geometry, as it is ordinarily conceived, leads to results of a nature quite different from those which are furnished by algebra, and a fusion of the two might be followed by the loss of some of the principal advantages of each of these branches. The same for other subjects.

Yet other dangers present themselves and the committee holds that it is necessary to examine all with care, so that only those reforms which lead to real progress may be undertaken.

THE CENTRAL COMMITTEE.

F. Klein, *President*, 3, Wilhelm Weberstr., Göttingen, Germany.

Sir George Greenhill, *Vice-President*, 1, Staple Inn, London, W. C.

H. Fehr, *Secretary-general*, 72, Florissant, Geneva, Switzerland.

October, 1908.

NOTE OF THE TRANSLATOR.

L. C. KARPINSKI,

University of Michigan.

Reform committees on the teaching of mathematics and other branches have been active for several decades. Germany, France, England, Italy, the United States and even China have participated in the movement. It is a fitting culmination of this world wide effort that an international commission is to investigate the teaching of mathematics. This preliminary report of the Central Committee is destined to rank as one of the great milestones in the progress of the teaching of mathematics. So universal is its plan that it would readily adapt itself to investigations in the other fields of instruction. For this reason the report will interest all of those who work for improvement in teaching.

Official announcement is made by Professor F. Klein that the American delegates are the following:

Professor William F. Osgood, Cambridge, Mass.

Professor David Eugene Smith, Columbia University, New York City.

Professor J. W. A. Young, University of Chicago.

According to the Preliminary Report of the Central Committee, they will form an advisory council of some kind to assist in the work.

THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS ALGEBRA REPORT OF 1907.

MABEL SYKES.

South Chicago High School, Chicago.

Mathematics as an aid to fuller and more efficient life for all high school pupils, is the spirit of the C. A. S. and M. T. Algebra Report of 1907. To state the methods by which this may be accomplished seems to be the purpose of that report. Many of us believe that the fact that a large majority of our high school pupils do not go to the university, do not even finish high school, is a good and sufficient answer to those who do not wish mathematics brought down to the level of pupils in the ninth grade, but who do wish it taught as high up in the curriculum as possible, and taught from the scholastic point of view. Mathematics rightly presented is more valuable to a large number of first year pupils than anything we could substitute for it. It is because mathematics teachers believe this, that their subject is taught in the first year, and not because they good-naturedly allow other subjects to have the best places in the curriculum.

In accordance with this purpose and this spirit, certain features of the report deserve more attention than has hitherto been given them.

ORDER OF TOPICS.

According to the report the object of first year algebra should be to train pupils to solve problems by means of equations, and topics should be selected and arranged to serve this purpose. After calling attention to the fact that the traditional order cannot possibly do this, the report makes suggestions intended to guide any who wish to depart from this order. Some of these general principles are repeated below:

1. "If judicious use is made of the pupils' knowledge of numerical fractions, algebraic fractions with numerical denominators may be introduced from the first.

2. Transposition of the terms of an equation (and elimination by addition and subtraction) involves only addition and subtraction and may be taught with these topics.

3. Elimination by substitution and the solution of fractional equations with numerical denominators, are possible as soon as the pupil understands the simple bracket and the multiplication of a polynomial by a monomial.

4. Multiplication of powers beyond the first, when bases are alike, and long division are rarely if ever needed in first year problems.

5. Special square roots and simple quadratic equations are possible as soon as the pupil can write $(a+b)^2$ and $(a-b)^2$.

7. The solution of a pair of equations in two unknowns, in which one equation is quadratic and one is linear, may be given immediately after quadratics.

13. It will be seen, therefore, that most of the different kinds of equations suitable for the first year work, may be taught before fractions, before factoring, before long division, even before multiplication of powers of like bases. This early introduction of simultaneous and quadratic equations increases vastly the scope and variety of the problems that can be given."

The order here suggested is the result of actual classroom experience extending over a number of years. In 1903, a committee of the Mathematics Section of the Chicago and Cook County High School Teachers' Association made a report which embodies many of these principles. This report was printed in the "Appendix to the Proceedings of the Second Annual Meeting of the Central Association of Science and Mathematics Teachers," in the same year. That report contains the following paragraph:

Leave drill work in factoring, fractions, theory of exponents, etc., until all of the different kinds of equations in the first year's work have been given. Then carry miscellaneous problem work on with the drill work.

Many of the changes suggested have been used for some time by thoughtful teachers, and are embodied in many texts; for example, special cases of multiplication and factoring should be taught together. (C. A. S. and M. T. report, principle 9, under order of topics.) On the other hand, other proposed changes have not been embodied in texts and involve a more radical departure from scholastic methods. They originally suggested themselves as quite satisfactory solutions for some long-standing class-room difficulties. Two illustrations will suffice. Whenever a large system of schools is involved and pupils who enter the high school have had some algebra the year previous, the chief difficulty is the unevenness of the preparation. One teacher who found a number of his pupils eager to use simultaneous equations in solution of problems before they had reached the subject in the text, gave the topic to his entire class when they were studying addition and subtraction. Thus the difficulty was solved and the recitation enlivened, as many problems could then be worked in two ways. Most geometry teachers deplore the fact that the majority of geometry pupils know nothing of quadratic equations. One teacher who taught both algebra and geometry introduced into his algebra classes the change involved in principles 5 and 7 above, believing that, had he time for repeated drill on quadratics in algebra, he would have less trouble in geometry. The results fully justified the experiment.

At this time there were no texts written which were of material assistance. Letters sent to more than thirty publishing houses about three years ago failed to reveal any text of the kind desired except Evans' Algebra, published by Henry Holt. Some of us drew much inspiration from Mr. C. E. Comstock, of Peoria, Ill. Typewritten copies of his book, which was not then in print, were found very suggestive as to order of topics and subject matter for problems.

The changes thus proposed were found to be practical and pedagogical in ways not at first appreciated. One thing led to another and the new scheme grew until, in more than one school, a fairly consistent course was evolved with the solution of the equation as the controlling idea. Compared with the course given in current texts, such a course has a clearly defined unity which the other lacks. This is, in itself, a great factor in producing a lasting impression, for the main point remains in memory and serves as a basis for the recall of details. Much more is this true when the fundamental aim has a visible practical bearing and the impression made is on adolescent minds. In such a course the solution of the different kinds of equations must come first, and everything bearing upon this must be given the place of prominence. This throws into the background certain cases of factoring, and fractions. It brings forward simple radicals as facilitating the solution of pure quadratic equations as applied to the solution of certain geometry problems. Such a course discards all exercises given for mere drill, when that drill is not on something in itself worth while; as for example, complicated brackets, complicated complex fractions, highest common divisor by division, and extended study of theory of exponents. Such a course gives prominence to things that interest boys and girls, inasmuch as the early introduction of the different kinds of equations makes it possible to give many problems having a geometrical bearing. Moreover, more intelligent work will be done on the more abstract topics given later, when there is a good foundation laid in the concrete and practical.

The order here suggested may be used with any text. The objection frequently made that there is danger of assigning exercises which involve work in advance of the class, is vastly over-estimated, and is usually made by persons who have not taken the trouble to verify the principles quoted above. It appears extremely trivial when attempt is made to furnish evidence

from current texts. The exercises selected from any list for introduction earlier than was intended by the author, are easily found by inspection. The equations involved in problems are extremely simple except in a few cases where the problem is so artificial that it ought to be omitted entirely. A teacher who does not care to plan courses, must of necessity follow the text. But, surely, university instructors are not the only ones privileged to plan courses. The changing of the order of algebra topics is comparatively easy.

CLASSIFICATION AND GRADATION OF PROBLEMS.

The rearranging of the topics in algebra may be simple enough, but any teacher who tries to train his entire class to solve problems is face to face with a serious question. Indeed, one is tempted to think that the entire mathematical fraternity regards the problem as an interesting little side issue to be disposed of as is convenient without taking too much time from algebra proper. Using only the material provided in the text that he may be using, it is hardly possible for the teacher to do more than to conduct a sort of mathematical entertainment made up of an exhibition of the feats of brilliant or fortunate pupils.

The fact that we have placed pure and applied mathematics in compartments as truly "water-tight" as those in which algebra and geometry have been placed, does not seem to offer a complete explanation. Take for example, problems involving number relations. They certainly belong to the realm of pure mathematics. Pedagogically they are valuable, for the translation of equations into number problems, and number problems into equations, gives most excellent training in the meaning and use of the algebraic notation. Yet it is rare for any list to contain half a dozen of these problems. The teacher who wishes to use them must spend time and effort to collect a sufficient supply, have his list type-written and distribute the same to his class.

The case is the same for every type of problem that can be named. Even when a fair number of problems of any one kind can be found after diligent search in any one text, no attempt at gradation will be encountered and the easier ones are usually not to be found at all. If any particular type of problem is chosen, and any half dozen recent texts are studied with regard to the treatment of that type, some astonishing things will come to light. Take for example, the problems involving uniform motion [d=vt]. In making such a study several varieties of

these problems will be met. Some of these are given below. It will be noticed that each case may cover one or more sub-varieties.

I. Problems that deal with bodies that start from the same place, in the same direction at different times. One body overtakes another.

II. Problems that deal with races.

III. Problems that deal with bodies that start from different places and travel towards each other.

IV. Problems that deal with a resultant motion when the forces act in a straight line.

V. Problems that deal with a body that changes its rate of motion at a certain point in its path.

Any list of thirty or forty miscellaneous problems contains ten or fifteen of these velocity and distance questions, among which are represented all of the above varieties or more, with only one or two in the list simple enough to illustrate the general conditions of the case involved. Moreover, the first of these problems introduced into the text at all, are often of the more complicated kinds, and even when sufficiently simple are scattered along one and two at a time, forty or fifty or more pages apart. One text introduces them by a complicated general problem under Case II. above. Another text introduces them by clock problems, which are a variety of Case I, and will not be clearly understood until Case I. has been fully discussed.

Classes can be trained to solve velocity and distance questions, but to do so it is necessary to isolate each case and to present simple problems under it until there is no doubt but that the class has grasped the situation. Then harder questions under the same case can be given. This can not be done with the use of current texts. It may be that it would be better not to teach velocity and distance questions at all. That is another matter. It does seem as if authors of texts might give the subject of problems a little pedagogical consideration. There seems to be hardly one who has any appreciation of the necessities of the case. A good discussion of the manner in which physics problems are introduced, is found in a paper by Mr. H. B. Loomis, read before the Mathematics Section of the C. A. S. and M. T., 1906, and published later in *School Science and Mathematics*. The suggestions made in the report concerning classifications and gradation of problems are of the utmost importance.

Treatment of Radicals.

Valuable suggestions frequently made in regard to the treatment of radicals suitable for first year high school pupils, are unfortunately not given in the report. In the report mentioned above, printed in the "Appendix" in 1903, the following paragraph occurs:

"Teach addition, subtraction, etc., of radicals as time savers in practical examples. For example, give a problem in which $\sqrt{18}$, $\sqrt{50}$, $\sqrt{32}$ must be combined, and let the pupil extract all the roots. Then show him by analogy with $\sqrt{a^2b}$ how he may save work. Have pupils always reduce surds to approximate decimals."

Similar suggestions were made in a paper entitled, "A Few Deficiencies in the Teaching of Mathematics," read by Mr. C. E. Comstock before the Mathematics Section of the Chicago and Cook County High School Teachers' Association in 1905, and printed a year or more later in School Science and Mathematics. The writer firmly believes that this is the only way to teach radicals to first year high school pupils. Discussions should be confined to the following types:

$$\sqrt{a^2b},\ \sqrt{a}\cdot\sqrt{b},\ \frac{\sqrt{a}}{\sqrt{b}},\ \sqrt{\frac{a}{b}}.$$

This should be followed by mensuration problems, as suggested in the report.

In General.

A course planned after the above suggestions is in accord with the newest psychology, with the best pedagogy and with the trend of modern education.

Mathematics teachers judging from the standpoint of the old psychology, have long insisted that mathematics is especially adapted for mental training. Now, however, we are told that power in general cannot be cultivated, that the mind is not a collection of faculties each subject to separate training, and that we must prepare for fuller and more efficient life. We are beginning reluctantly to conclude that other subjects may do this just as well, perhaps better, than our own. Yet for some pupils, at least, mathematical efficiency is of the utmost value. This efficiency certainly includes as one very important factor some definite mathematical knowledge, and the power to use the same when the need arises. There is no us in deceiving ourselves.

As far as all observation goes, our pupils acquire very little of this power from the algebra course as traditionally planned. A course that throws emphasis on the useful, should give very different results.

Throughout history the best teachers have repeatedly told us that good teaching proceeds from the particular to the general, from the concrete to the abstract, from the simple to the complex. Do the miscellaneous lists of ten or a dozen different types of problems from which the vast majority of the easier ones have been religiously excluded, conform to this law? Certainly carefully classified and graded lists proceed from the simple to the complex far more truly. Can any better defence be made for the traditional order of topics? Surely long division, complicated brackets, the factor theorem, complex fractions, and theory of exponents, are neither concrete subjects nor special cases. No more are equations and problems, usually deferred until after fractions, the most general and abstract topics. Is there any justification in the history of pedagogy for giving the complicated abstract manipulations before the concrete and the useful are more than mentioned. We need not take refuge in university practices, for educational reforms rarely originate there. The fact is, the order of topics in our algebras is made by the specialist as he reviews a subject with which he is familiar. It is beautifully logical from the standpoint of abstract algebra, but does not appeal at all to the fourteen year old boy or girl in whom is just dawning the appreciation of himself as a social unit. His inevitable question is, of what use? And he will not be put aside. Moreover, all modern society is clamoring for a more useful education.

There is no doubt whatsoever that the equation is the useful thing in elementary algebra and that its use lies in the solution of problems and the manipulation of formulae. If we have any faith in modern psychology, if we read aright the laws and the history of pedagogy, there is no escape from the conclusion that a judicious mixture of pure and applied mathematics must make up the subject matter of a course whose central and controlling idea is the equation.

We need above all things a reform in the way in which problems are presented in our texts.

THE PRACTICAL USE OF BIOLOGY.

Editor's Note: The following paper is the report of a committee of teachers of biology to the Section of Biology of the High School Teachers' Association of New York City. The report is made in accordance with instructions to prepare a paper which would outline the practical uses of the study of biology.

INTRODUCTION.

The signs are clear that a new era in education dominated by the idea of training in subjects that are useful is upon us. The first enthusiasm for the new idea demands that boys and girls shall be taught subjects that will aid them in making a living. If continued thought admits the usefulness of subjects that also train *in living*, then the range of acceptable subjects increases, as the conception of life broadens.

The teaching of biology in the high schools is passing through a period of rapid transformation. From the set presentation of the principles of the science with incidental application to human affairs, we see a definite change of emphasis to man himself in his biological relations. In this modification of former points of view it is evident that teachers of biology are desirous of bringing their subject into line with other agencies that are contributing to the improvement of man's well-being.

The experience of teachers has shown that in a well organized course in biology practical applications of the subject can be made to many interests of man. Some of the most important of these applications are discussed under the topics of the subsequent sections.

Economic Phase of Biology.

The subject of biology furnishes much of the information as well as suggestions of means for preserving our natural resources.

There are many plants and animals, and many organic processes in nature, of which mankind makes direct use; it is important that those who have to do with these plants and animals and processes should understand these things. But very few of the boys and girls in our city schools are to become farmers and fishermen or foresters, or even physicians; and if any of them do follow up these callings they will not do so on the basis of the year of biology they can get in the high school, nor will anyone be able to dispense with the services of a physician in sickness because of having studied biology in the high school. Nevertheless

there are many points at which the practical welfare of the people touches the biology which every pupil can get.

The economic welfare of the people rests upon the economical utilization and husbanding of the natural resources. The conduct of the citizen in relation to the natural resources of his community or nation will depend to a very large extent upon the realization of the importance of the various factors to the life of the community and of the members of the community. Such a realization can be acquired only by learning at a proper time and in a proper way of the relations between man and the living part of his environment.

To understand wherein the "fertility" of the soil consists, its relation to plant and animal life, how it may be preserved, is of great practical importance to the farmer: the farmer who does not understand these things will fail as a farmer. But to the extent that all the citizens understand these things, whether they are farmers or not, the soil of the nation will be protected and preserved as to quantity and quality.

To understand the conditions for the growth and renewal of forests, the enemies and the friends of the forests, is of great importance to the forester and the lumberman; but it is of greater importance to the whole people that each citizen should understand the relation of the forest to the welfare of the nation. Such an understanding would make impossible the shameful waste that has been going on for the past fifty years; a nation with this understanding would not tolerate the spectacle enacted in our last congress, of that body refusing to appropriate funds to fight the mistletoe which is destroying the oak trees in some of the states, on the pretext that it was placing sentiment above dollars! A nation with an understanding of the value of its trees, would not tolerate the disgraceful frauds connected with the seizure of hundreds of thousands of acres of the people's forest lands.

It is important to the fisherman to know something about the habits of his prey: but it is more important to the community that it shall regulate the contamination of its streams and prevent the depletion of its fish supplies with some regard for the morrow. The factory owner who throws waste poison into the river and the wholesale fisher are concerned with quick profits; but the community continues to need its fish supply after the individual is gone. Its only safety lies in a public intelligence that will not tolerate anything that is inimical to the general welfare, even in the name of enterprise and business success.

The practice of hunting rests upon the individual's interests or pleasure; the restriction of hunting as to seasons and territory and as to species of birds and mammals killed, rests upon the larger need of the whole people. It is possible to have sane laws in these matters, and to carry out their intent, only when the general public both realizes their importance and sympathizes with their purpose.

The boy who learns in his course in biology the reason for killing mosquitoes and sparing lady-bugs may not be the richer personally for the information, but the community that learns to kill its mosquitoes and to spare its lady-bugs will surely have an incalculable balance in its favor.

While it is not necessary that every individual receive a technical training in all the specialties, it is not sufficient that there be experts who are thoroughly familiar with the technical details pertaining to the utilization and preservation of the natural resources. We have experts on gypsy-moths and on mosquitoes, and on Russian thistle and on lobsters and starfish; it has not been possible in the past to prevent through the activities of these experts and their corps of assistants the stealing and waste and destruction of the people's wealth. There is no reason to suppose that an increase in the number of experts and in the size of the corps of their assistants will be more successful in the future in preventing the undermining of our economic welfare. It is necessary that our legislators be better informed on the fundamental conditions of our very existence in the midst of the organic world; and it is necessary that every citizen should be in hearty accord with the efforts of the official agents of the population in protecting and preserving the nation's wealth. There is no way apparent for securing this understanding on the part of the legislators, who are chosen at random from the population at large; nor for securing this sympathy on the part of the unofficial portions of the population, except that of teaching to all who may be reached the fundamental principles of plant and animal life and the relations of these to the life of man.

Health Phase of Biology.

The relations of foods to the efficient work of the animal body, the importance of pure food and safe medicines, the cause and prevention of disease and the proper regulation of personal habits, together constitute a practical phase of biology of direct importance to every individual.

Statistics show that eighty per cent of the school children of this country are suffering from some irregularity of the eye, ear, throat or nose, and that fifty thousand children are taken from school annually because of some physical debility or nervous condition. In view of these facts it is high time that accurate knowledge of the conditions conducive to health should be extended as widely as possible. It is in the hygienic phase of biology that we find the proper exposition and experimental demonstration of four requisites of good health: proper food, sunlight, fresh air and temperate habits.

In teaching the subject of foods to children who have been accustomed to follow the craving of the moment, advice counts for little. When it is explained to pupils that food supplies the body with tissue and with its store of energy, they become interested in experiments and discussions bearing on the topic.

The plant and animal sources of food, and their relative value in contributing to human needs may be made the subject of class discussion without delving far into organic chemistry. Laboratory work in elementary biology, though hardly scientific except in demonstrating scientific method, gives the pupils abiding interest in the subject of pure food. Immediate results of study of this kind have been seen in more wisely chosen school lunches. This means, furthermore, that the light has penetrated the ignorance of many a benighted home.

There are other ways in which the study of foods in the schools can result in benefit to the general health of our citizens. In the first place, the experiments being carried on by physiologists are furnishing us an increasing supply of knowledge bearing on the relation of foods to man's physical needs. These facts should be widely disseminated. The public would then be placed in a position of security from the injurious effects of ill founded traditions of what is good or bad in food, as well as be protected from the unproved fancies of more modern sources.

Again our pure food laws need the support of a body of people whose training has been such that they comprehend the reason for those laws. The understanding of this subject by the people needs to be so clear that aggregations of selfish interests shall not deprive us of the gains we have already made in legislation for unadulterated foods.

No less important for the public health are safe medicines. The schools have it in their power to show the reasons for giving over

the treatment of disease to those who are scientifically trained for that work. One of the greatest sources of danger to persons in uncertain health is the prevalence of brands of proprietary medicines. The producers of these medicines make what everyone knows to be unwarranted claims for their mixtures. Doubtless they are also responsible for imposing destructive or debilitating habits on many who turn to them in the hope of being relieved from pain. We have awakened to the necessity of fighting communicable diseases, but there is no organization to warn the people of the danger from poisonous medicines. Here again in the organized course in general biology is the place to lay the foundation for temperate care of the body in choosing carefully what shall be taken into it.

A number of organizations in this country are striving to arouse the adult public to a realization of the fact that the disease of tuberculosis is on the increase. The task of convincing people, and especially of bringing about an actual change in habit, is simpler if undertaken through the schools. In a well organized course in biology the facts about communicable diseases come out in their true biological relations. The life history of the organisms that carry diseases are studied enough to give information about the conditions favorable to their existence. Through this information organized society is furnished with a scientific base of operations against tuberculosis, typhoid fever, malaria, yellow fever and other diseases transmitted through organisms.

The organizations of citizens that try to inform the public of the nation's danger from disease are obliged to expend tremendous energy to arouse interest in many parts of the country. The efforts of these organizations can be supplemented perhaps with far less effort by teachers of biology. Pupils can learn that the scientific method of biology has been used to discover the causes of diseases, the conditions under which diseases exist, and ways of checking them. Thus respect and support for science may come with the knowledge that through it we have learned to prevent to a considerable extent enormous waste of life.

Out of much conflicting testimony and opinion bearing on the relation of habits to man's physical well-being, we are now practically certain that all well known "bad habits" either lower a man's vitality or leave him in an irritable state. The schools are gradually giving up the teaching of temperate habits by frighten-

ing the pupils. The facts, even though less startling than formerly supposed, are more convincing because of their practical certainty. The course in biology offers the opportunity to discuss the effects of alcohol and narcotics in their relation to physiological processes. Whatever advice teachers may see fit to give, their teaching is fortified by a real scientific reason. It takes this to be convincing.

The fight that society has made in the open against the evils of sumptuary excesses has long been accompanied by a desultory or timid struggle against the more gigantic evils of abnormal sexuality. Uncertain as we are still of the best methods of abating these far-reaching evils, we do know that the first step towards success in it must be the frank and open but methodical teaching of the facts of sexuality and reproduction to the young.

In the period of adolescence the child is intensely interested in his own physical nature. Up to this time his parents have been responsible for his health. They have regulated more or less wisely his habits of life. Now he is beginning to assert his independence and to choose for himself. Parental advice and rules of ethics are frequently inadequate to curb the new impulses which are now coming so strongly into the foreground. What do all these impulses mean? Are they sinful? When the youth, carried away by his abounding energy, breaks one rule of hygiene after another and sees no immediate ill effect, he begins to doubt the necessity of depriving himself, and he may squander the physical capital which should be reserved for future years. This danger threatens alike boys and girls who are ambitious students and those whose temptations lie in other directions. This unsettled state of mind is just beginning when the youth enters the high school. If he is then furnished with sound ideas of what a living organism is, of the conditions favorable to its normal growth, and of its duty to its species, he will apply it more and more fully to himself as time goes on.

The first organisms studied may be a flowering plant. He watches the embryo of the seed develop, fed at first wholly, and then partly by food stored in the seed by the mother plant. He learns the proper conditions of air, water, sunlight and food, which are necessary for its successful development. When at last it is able to depend entirely on its own exertions for its food supply, he finds it storing up some for future needs. When this period of growth has reached its height, he finds the plant

entering on another life stage. It begins to blossom and bear fruit. It is no longer independent, but depends upon other individual plants for pollen, and on insects and other animals for pollination and seed distribution. All the accumulated food capital and all the energies of the mature plant are now expended (if it be an annual) on the development of embryos, in providing them with food for the period of germination and in the development of a fleshy pulp or other means of disseminating the seeds.

A less detailed study of the life processes of simpler spore-bearing plants reveals in these organisms the same conditions as necessary for life, and in their life history the same periods, a period of growth and development, and a period of reproduction or of life for the good of the species.

The simpler animals show the same needs and life-periods, and the life histories of insects impress the lesson still more deeply.

In the higher animals and in the part of the course devoted especially to man, the time is best spent in emphasizing the conditions which are favorable to the healthy development of the vegetative organs, thus showing that the rules of hygiene are not arbitrary regulations set by parents and teachers, but the expression of laws governing the whole living world of which he is a part. His kinship to other living things being realized, he has, as in a parable, been taught his duty to his race. Many questions which have been arising in his mind have answered themselves naturally, and the whole subject of reproduction has been placed on a healthy and sane basis.

Culture Phase of Biology.

Biology supplies an intellectual stimulus for a sympathetic interest in nature and portrays the interrelation of man and other beings. Through all ages thinkers have recommended to man, as the ideal of knowledge, the understanding of himself from many aspects, from the structural, the social, the political, the psychical and the ethical. Yet all these viewpoints must manifestly be imperfect unless they include an understanding of man as only one of countless types of life.

A proper conception of man's environment is a rare possession, but its acquisition often affords a source of pleasure so keen, and affects conduct so favorably that the opportunity of obtaining it should be universal. Abundant evidence is at hand to prove that the study of biology has successfully opened the eyes of

many of the young people to whom it has been taught. Among these are numbers who rarely leave the city, but who have learned to see, to interpret and to enjoy the bits of nature that the city still retains. Even a little knowledge of other forms of life discloses a new world to the eyes of naturally indifferent persons, and leads them into the contemplation of interests beyond their immediate personalities.

Such knowledge, too, usually quickens the sympathies. Very deep rooted is the belief that man has been placed in the middle of a universe created especially for him—that every living thing must have some immediate reference to him, if not for good, then for ill. Biology teaches the youth that, at bottom, all life is the same. It shows that, in the end, all the complicated life activities in any animal resolve themselves into a few primal instincts—those of obtaining food, of begetting offspring, providing for them, and—their individual existence assured—of helping their own kind against their enemies. This broader outlook upon life tends to restrain some of the baser impulses. Pupils seem disposed to cease annoying defenseless creatures about them. Ruthless injury and uprooting of young trees and other flowering plants also tends to cease, when the pupil has learned something of the time and labor expended by the plant in reaching the stage of development where it attracts attention. Respect and sympathy for life of other kinds, and, as a consequence, of his own kind is, therefore, the end obtainable through such knowledge.

Biology leads us to understand that everywhere around us is going on a perpetual cycle of change: Plants are converting water, gases and the soil constituents into their own substance; out of the plant parts, the animal is constructing its cells and eventually both plants and animals, by their decay, return to the earth what for a short time was borrowed from it. In the midst of the complicated biological relations of organisms, stands man with his intelligence—the source of his supreme power. When the understanding of the dependence of organisms upon one another, and the dependence of all upon nature's inorganic resources becomes general, cruelty and waste will tend to disappear. Men will command and direct the levies made upon nature's resources with intelligent consideration for the generations of men to come.

Disciplinary Phase of Biology.

The development of the habit of accurate thinking is a serious need in civilized life. Biology offers the data and the method for making training of this kind effective.

The only important mental discipline is that which is effective when applied to the problems of everyday life. In the past certain studies which made up practically the whole of the traditional college course were supposed to possess almost exclusively the power of developing mental discipline. It was then thought that reasoning power, developed in any way, is directly applicable to solving problems of any kind where reasoning is demanded. The frequent failure of the man who has developed a rather high degree of power according to these standards, to solve successfully the problems of modern life, has brought into question the accuracy of this theory. Moreover, the results of modern psychology show that the mind is not made up of faculties each of which is susceptible of being independently trained.

Educational experiments have shown that there are two ways in which a study may develop the mental power which may be applied to the solution of the problems of modern life.

First: Discipline or power developed in the study of any certain subject matter is of value in dealing with other subject matter just so far as there is a similarity in conditions and data.

Second: There may be developed in the study of a subject a certain ideal way of handling facts. When a pupil finds by experience that conclusions are valid only when based upon the results of carefully weighed observations and experiments, he has developed a habit of thought that is of value in dealing with any set of facts. He has at his command an instrument not only of value in solving his own problems and arriving at conclusions which he is able to defend, but an instrument with which he is able to examine critically the conclusions of others. He will be able to distinguish between inferences as certain, probable and possible. He will have learned that to be an authority on any subject he must have a wide knowledge of the facts of that subject. This ideal of thought, which has been called the scientific method of thought, developed in dealing with one set of facts, is invaluable in dealing with other facts.

Science training by which the pupils are brought into actual contact with facts and led to drawing conclusions from these facts, is valuable in awakening high school pupils to a realization that it is their right and duty to think for themselves.

In the light of what has been said about the conditions for training in mental accuracy, biology is peculiarly adapted to that end. The very essence of biology is the study of problems of life.

The scientific method of thought is capable of immediate application to the problems that urgently require solution in human life. No closer relation between the conditions of a school subject and life itself could exist.

SUMMARY.

Biology contains in organized relation many applications to human life. Many of these applications would never be developed in other subjects of the high school course.

It is of vital consequence to the nation that its citizens understand the importance of preserving its natural resources for future generations of men.

It is of more consequence that the young realize the need of guarding our greatest resource—the health of the people.

The comprehension of man's place in nature and the interdependence of all creatures of nature, contributes to satisfaction in living, and it offers a scientific basis for the work of preserving the public's resources.

The methods of biology give a good opportunity for training in habits of mental accuracy by the scientific method of thought applied to problems of real life.

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FIELD WORK ON BIRDS FOR CITY SCHOOLS.

By Lynds Jones.
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One might be pardoned for assuming that studies of birds is impracticable in city schools. Fields and woods and swamp are either not accessible at all or cannot be reached in the short period given to this subject. It is usually not satisfactory to give longer periods once or twice a week to this sort of Nature work, because too much momentum is lost in the intervals. The problem is then one which must be treated like that of any other subject in the curriculum. This is my method of attack:

If there is a tree, or shrub, or bush, or post within fifty feet of a convenient window in the school room—a window not regularly used—fasten a food box where it can be plainly seen from the window. If there is no such place for fastening it either make one, if that is possible, or else fasten it to the window sill. The birds will not come to the window sill box as soon as they will if it is farther away, but in time they will. Keep the box supplied with food. Table waste, nut meats, grains, chopped meat, or not too clean bones answer every purpose. Chunks of suet tied or nailed to any support above the reach of cats and dogs, and not in or on the food box, will help to attract some birds.

Have the children keep away from the box at first, but encourage them to notice any visitations, either by watching from a distance or in hiding, or by the disappearance of the food. Of course English Sparrows will be the first birds to eat from the box. Remember that even they are birds. It is almost certain that in time other birds will become regular visitors. Begin the studies on the Sparrows just as soon as they will permit inspection while they are feeding.

The children should be given just as little direction as possible, but be encouraged to notice everything in as much detail as possible. They should work in small groups, never more than four at a time, and the groups changed as often as inattention is apparent. The ideal method would be for these observation studies to be scattered throughout the day whenever there were birds to observe. At any rate the Nature study period should not usually be given to such observation studies for the whole class, but only for as many small groups as could be accommodated. The recitation period should usually be given to hearing reports from pupils who had made observations, each pupil being given a definite time

to make the report. In these reports strong insistence should be placed upon clearness of statement, accuracy in describing the facts noted, and the use of good English. Imaginings should be discouraged. The first object in these observation studies being training of the perceptive faculties and clearness of statement in describing what is seen, the facts learned are of minor importance. I would dispute only manifest absurdities. Most inaccuracies will be corrected by subsequent observations, and it is usually far better to let the children discover them than to have their teacher attempt to convince them of error against their will.

While the teacher may well point out the usefulness of careful note-keeping, I would not overly much insist on note-keeping, unless there is an evident tendency to looseness of observations resulting from its lack. There is no objection to having notes taken during the observations read provided they are not too long or too prosaic. Such papers may be handed to the teacher for inspection, if that seems desirable. In fact, anything that will tend to bring out the originality, or its lack, in the pupil may well be encouraged. It is safe to predict that this exercise will reveal traits of character which are certain to greatly aid the teacher in her dealings with the pupils in other work as well.

An important feature of this work will be to urge each pupil to have his own home food box. By so doing the parents are pretty certain to become interested. Much side light will almost certainly be thrown upon the work of the school from these private studies. Occasional brief reports from this work will prove a profitable diversion.

It is not possible to give specific directions as to what facts should be expected from this study, because conditions will vary with the situation of the school house and with the environment. In fact, the less cut and dried you can make the study the better. One can only say that you are after everything relating to the life of the birds as exhibited at the food boxes. Of course if you have access to woods or fields or ponds you will make occasional excursions to such places, but you will do well to concentrate your efforts upon this work as outlined for the immediate environs of the school building. You will accomplish far more and with far less effort. If you object that you know nothing at all about birds and could not attempt to try to guide children, I reply that you probably know as much as most of your pupils, and should be capable of learning more easily than they. At any rate, whether

you know them or not the facts are there and you have set the pupils to discover them. If you will turn them loose among the facts they will be certain to absorb some of them, and in the process will have acquired a habit of attention and a capacity for clear and accurate statement of what they know.

Finally, try to impress each pupil with the fact that each bird is a personality. It is not easy to learn to recognize individual birds, but it can be done, because it has been. No directions can be given here. Each pupil must work it out for himself.

SOME PRACTICAL ELEMENTARY CHEMISTRY.

By Fredus N. Peters,

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In the round table at the Thanksgiving meeting at Chicago of the Chemistry section of the Central Association, a number of very interesting phases of practical chemistry was mentioned by various teachers present. In the course of the discussions the use of hydrochloric acid and sodium bicarbonate, instead of baking powder, for making biscuits was suggested by the writer, and he was asked to give the details of the experiment as carried out by his students.

The subject of baking powders had been discussed in class and the question raised as to what substitutes might be offered for the leavening agents now upon the markets. Would common marble with hydrochloric acid do? If so, why? If not, what objection? Would common soda and hydrochloric acid do? Considering it as to the residue left in the bread, how would it compare with the ordinary baking powders?

It was proposed to the pupils that they make the matter one of practical experiment; to this they readily assented. The trouble came when the proposition was suggested at home, for many of the mothers, and especially the domestics, not understanding the chemistry of the case, felt sure they were to be poisoned by the "acid." As a result much of the work was done by the girls and boys themselves, who, not skilled in cooking, did not have as great success as might have attended other hands, accustomed to doing such things rapidly. It is well known that much delay in the baking after the dough has been made up is fatal to best results with any powder.

The writer prepared a lot of specimen tubes from heavy glass

tubing so there would be no danger of breakage on the way home; also a considerable quantity of hydrochloric acid of such strength that 10 cc. would exactly decompose an ordinary teaspoonful of soda. The specimen tubes were numbered and filled with the acid. The students were furnished with the following detailed instructions:

"Sift one teaspoonful of soda with one quart of flour, as usual, so as to mix them thoroughly; do not add any salt. Work in the shortening in the usual way; add the acid to the water to be used in making up the dough. If milk is used instead of water stir constantly while pouring the acid into the sweet milk. Mix the dough as usual and bake as soon thereafter as possible."

Referring to my note book I find the experiments began Feb. 23 and continued daily for about two weeks. Twenty-four experiments in that time were made by the boys and 42 by the girls. Some of the students repeated the work once or twice. The following copied from the note book kept at the time will give an idea of the results:

No. of tube	Date	By whom	Liquid	Flour	Result	Remarks
9	2-23	Dorman	Water	White	Fine	Not enough salt
1	"	Peters	"	Graham	Good	.....
3	2-24	Thornton	Milk	White	"	.....
20	2-26	Russell	"	"	Fine	Fig layer cake
28	2-28	Runnells	"	"	"	Spice cake
34	2-27	English	"	"	Excel.	Sponge cake

These are but a few, yet fair samples, of the entire record. Every morning during the continuance of the experiment, the chemistry department before school was a "clearing house" for the various products from the home kitchens. Biscuits of every description, from those beautifully browned and artistically shaped, to those anaemic in appearance and distorted in form, were shown with, apparently, the same degree of pride. Likewise, muffin cakes, spice cake, sponge and layer cakes as appetizing as one ever needs to wish were brought in for inspection. On the whole the results were good, and when it is remembered, as has been stated, that much of the work was done at home by the students themselves, not accustomed to cooking, the results were excellent. From the viewpoint of the chemistry class room, the experiment was a great success and only a lack of time and engrossment by other work has prevented a repetition.

WERNER'S SOLUTION OF THE VALENCE PROBLEM.

By Jos. L. Coon.

University of Maine.

"The commonly accepted theory of valence has done more to prevent an advance in inorganic chemistry which should parallel the advance in organic, during the last few decades, than all other things combined." Such is the opinion of Prof. Alfred Werner; an opinion held also by many of the leading chemists of the world. Whether this charge against the valence theory is true or not, it is rapidly becoming the consensus of opinion among chemists and chemical students that, because of its inadequacies and manifest fallacies, the present system should be replaced by a better.

In opening our discussion of what may be, and in all probability will be, the theory of the future, it may not be amiss to mention the leading theories of the past and present and to show wherein each failed. All agree in their definition: that valency is an expression of the number of atoms with which the given atom can directly combine. Our concept of valence is reached only from the structural (pictorial) formulas proposed for the molecular constitution of compounds. Perhaps it would be a more correct expression of the actual state of affairs to say that the composition and structural determinations, experimentally made, enable us to deduce all that we call the theory of valence. The valence numbers—these being the numerical expressions of the combining relations of the atoms—are obtained from a classification of compounds of the first order. The atomic unions indicated by lines between the symbols, and the theory of valence are principally a systematization of the theoretical side of chemistry, based on experimental facts. The changes in our conceptions of valency have kept pace with the tendency of structural formula changes toward the development of nucleus formulas in which one atom has a central position about which the other atoms of the molecule arrange themselves. The number of affinity forces (valence bonds) available to the central atom must be indicated.

In Gay-Lussac's time—and indeed, up till the year 1851—it was held that the valence value for all atoms was the same. So water was considered as H-O, the chloride of iron as Fe-Cl, sulphuric acid as H-O-O-S-O-O-H. But in 1851 Williamson

noticed that the hydroxides of barium, calcium, strontium, etc., required more than one equivalent of hydrochloric and only one of sulphuric acid for neutralization. The polybasic idea of acids and hydrates immediately sprang up and very soon came to be accepted. From the fact that ferric hydrate required three equivalents and barium hydrate two for neutralization, and so the molecules must be considered as $Fe(OH)_3$ and $Ba(OH)_2$ respectively, the idea of types naturally followed. These included the substituted water types, the ammonia types, etc., in which hydrogen was replaced by other elements. From the recognition of the polyvalent substitution equivalence arose the idea of the combining powers of the elements, and of the central formulas instead of the chain formulas, i. e., sulphuric acid was now considered to be $\begin{matrix} H\text{-}O \\ H\text{-}O \end{matrix}\!\!>\!S\!<\!\begin{matrix} =O \\ =O \end{matrix}$

Analysis and molecular weight determinations soon showed that under some conditions the atom was stronger than under others. That is, the chloride of iron was sometimes $FeCl_2$, and sometimes $FeCl_3$. But it was also noticed that the tendency was for ferric chloride to break down to ferrous chlorid. Naturally this gave rise to the idea of varying valence and caused Keküle to propose his theory of "atomicity." He proposed this term to indicate the holding power of an element. This, he thought, was a constant quantity—"as unchangeable as atomic weight itself." According to his hypothesis, as the valence increased, the amount of atomicity, i. e., holding power, represented by each valence bond necessarily decreased, hence the compounds of the lower valence were the more stable. The few cases then known and the innumerable number since discovered which have the greater stability at the higher valence were left unexplained. Because of these exceptions we are thoroughly convinced today of the untenableness of his notion. However, the theory of varying valence has changed but little since his time.

It is hard to say what will take the place of this idea with its striking simplicity. However, it is evident that we must seek a totally different explanation of the valence problem. The new theory must propose and explain these factors: (*a*) the change in the valence of elements, (*b*) the limiting values of the valence numbers, (*c*) the valence unit as a directed single force, (*d*) the electro-chemical conception of valence, (*e*) the unsaturated unions or so-called double bonds, and (*f*) the relation between the affinity and valence. It must also explain the compounds of the higher orders and their co-ordination numbers.

The first and fundamental law in the theory of valence today is that the valence of an element is not a constant but a variable; certain atoms show for other atoms differing grades of valence, varying with the conditions under which the experiment was carried out. The change is not by units as was formerly supposed, but by differentials. Molecular weight determinations have shown the proposed explanation by cross saturation of the extra valence to be untenable. We must assume varying valence values for each element and in giving the valence number, give them all, —or rather, give the limits within which the value varies. Then, too, the given element shows a valence varying with the nature of the uniting element. The maximum and minimum here do not agree with the maximum and minimum of the values between the two given elements. There is not even an approximate agreement. From the valence for oxygen or hydrogen we cannot tell what will be the valence for nitrogen, chlorine, etc. We cannot, therefore, speak of a unitary concept of valence. True, with a vivid imagination, we may assume a large number of unsaturated unitary valences in the lower valence compounds, but it is easier to conceive of valence as a variable quantity changing with the element in question.

From experiments it is evident that the value of these variable quantities depends to a large extent on external factors. From the data from numberless experiments on the dissociation of compounds with the rise of temperature, it appears certain that the valence number not only depends on but is a function of the temperature. As a general rule the valence decreases with the rise of temperature. That the pressure affects the valence is shown by the fact that at a fixed temperature the possibility of the existence of certain compounds capable of dissociation depends on the pressure of the products of the dissociation. It is highly probable that other physical forces also affect the valence. Ferrous compounds change to ferric when acted upon by the electric current. It is a well known fact that certain compounds exist in solutions but not outside, and vice versa.

A question naturally arises as to the limiting values of the varying valence. The minimum undoubtedly is zero and it is probable that there is an invariable maximum value also for all elements. It is evident that this maximum value depends on the spatial relations about the atom. The problem has been worked on for several years, and here we will give only the con-

clusions drawn. Abegg, working under the old theory, gives as his opinion that the maximum value for all elements is eight. It is a phenomenon worthy of notice that the strong electro-positive elements show the largest valence for the other elements of high electro-positive strength, and vice versa, the electro-negative elements show a high valence for the other strongly electro-negative elements. Abegg further states that the valence does not appear to be a property of the elemental atoms themselves, but the result of the reciprocal action of the differing atoms in the compound. A compound can result only when the reciprocal attractions between the reacting atoms is greater than that between the atoms themselves. If the latter is the greater the molecule—if it forms at all—immediately breaks down and forms two or more simpler compounds. This explains the non-existence of the high oxidation stages, etc., which we might expect. As an example: From FeS_2 we would expect $FeCl_4$ would be formed on dissolving the sulphid in hydrochloric acid. But experiments show that this—if it does form at all—immediately decomposes and gives us $FeCl_3$ and Cl^0, so that the maximum valence of iron for chlorine is three. Prof. Werner well summarizes the conclusions on this question when he says: "The valence number can be considered as the resultant of the competing strength relations of the binding powers of the atoms. And since the strength ratios of the uniting powers vary between the different elements, so we should expect variations in the maximal valence of a given element for different elements. And it is clear that where the highest maximal valence numbers occur, the elements form a molecule with the least 'cohesive' force, i. e., the compounds are the most unstable."

It is a theory with some that the affinity of an atom acts through a fixed number of valence units. These units are supposed to act as single forces from fixed points on the surface of the atom. In addition, the hypothesis has been made that they act in fixed directions only. This hypothesis was proposed as an explanation of the stereo-chemical relations. But this hypothesis puts into the concept more than is warranted by the facts; it also requires some further hypothesis concerning the inner structure of the atom; it gives rise to many questions for which as yet we have no solution. It makes necessary the assumption that the atom is not homogeneous, the points where the valence forces act being different from the rest of the atom but like each other.

The question must then be brought up as to the relative positions of the differing parts, the direction of the action of the valence units, and the deviation in direction possible. It further calls for a definite assumption as to the shape of the atoms. It directly opposes the idea of varying valence, and so in cases of lower valence we would find it necessary to add the further hypothesis of mutual cross saturation between the unsatisfied units.

Strong arguments against the theory are found among the isomers of the carbon compounds: In racemisation, optically active compounds are changed to the inactive forms quantitatively. There must then be a motion of the radicals about the asymmetric carbon atom. To accomplish this the radicals may detach themselves and again add on in a new place. In this case we have every reason to expect that by-products would be formed. But as none are, this explanation seems improbable. The other alternative is that the points of valence force move over the surface of the atom. But this contradicts the directed force hypothesis and so necessitates the giving up of the theory. Again, in the cis-trans-rearrangement of geometric isomers we must either assume that the radical breaks its double bond, revolves, and again unites without the formation of by-products, or that one bond disappears, the radical turns on the other as on a pivot, and then the second bond reappears. Either of these is highly improbable. Moreover, the theory entirely fails to account for the cis-trans-addition compounds formed at the point of the double bond. The theory is full of self-contradictions and so is an explanation which does not explain.

In the electro-chemical concept of valence it has been proposed to take the carrying power of atoms for electricity as a measure of valence, since this carrying power varies so between the elements. The theory considers the electron—the quantity of electricity attached to the atom on dissociating as an "atom of electricity." A univalent element then is defined in these terms as a substance one atomic weight of which will take up .96540 coulombs of electricity on going into the ionic condition. A divalent element will take up twice as much, etc. It is not meant that chemical affinity has anything of an electrical nature, but that the affinity for electricity being more definite may be taken as a measure of the chemical affinity, since for some unknown reason these two seem to parallel each other exactly in compounds of low valence. The law does not hold for the higher

valences. Abegg and Bödländer have proposed a systemization on this relationship. Since, however, the principle is limited to dissociating substances, it is too narrow to serve as a basis of classification. The theory makes no pretense toward being an explanation of valence.

A further point which the accepted valence theory must explain is the unsaturated union or so-called double bond union. All that has been said before against the single bond, or valence as a directed single force, is, *a fortiori,* against the double bond argument. Moreover, the behavior of all compounds supposed to have a double bond show that they are not strengthened, but weakened by the union. They are much more sensitive at the point of the double union and for that reason are called unsaturated compounds. So far, no explanation has been offered for the fact that the unsaturated valences must be on neighboring atoms. Baeyer, in his "Strain Theory" has attempted to explain the weakening effect. But his theory is not capable of proof, while all that has been and may be said against the idea of valence acting from fixed points and in fixed directions is against it.

All commonly accepted theories fail to explain the variation in the degree of unsaturation, dependent on the nature of the substituents, in the ethylene derivative. By these variations we are forced to the conclusion that the doubly bound carbon atoms have a condition of saturation varying with the nature of the radicals united with them. This saturated condition is less than that expressed by the structural formulas but greater than the next lower degree of saturation expressible by valence formulas. The manifold gradations of the degree of saturation of atoms bound equally in the "valence chemical" manner, find no representation in the structural formulas. By assuming definite valence units we give up wholly the possibility of a complete representation of such gradation.

These difficulties vanish if we adopt Prof. Werner's idea that the uniting relations of atoms is on a broader foundation,—that of affinity rather than valence. Suppose the atoms as bodies of homogeneous material and, for simplicity's sake, suppose them spherical. With reference to affinity make the following simple assumption: (*a*) It acts from the centre out to all parts of the surface of the atom as an attractive force; (*b*) The quantity of affinity saturated in the union of two or more atoms is distrib-

uted over a certain circular section of the spherical surfaces of the atoms, and will vary widely with the nature of the atoms.

In this theory separate valence units could not exist. Valence would mean the numerical relations in which atoms unite one with another, independent of any idea of valence units, for it would depend not on one atom but on all the atoms in the molecule. By this means we can form a satisfactory representation of the varying uniting relations of the organic and inorganic atoms. The arrangement of uniting surfaces dependent upon the size ratios leads without further auxiliary hypotheses to structural formulas. Stereo-chemistry, racemisation, the rearrangement of double bond isomers, the stability of ring formations, the conjugate double bond addition compounds, etc., are all simply explicable. Prof. Werner's theory not only does all that the old theories could do but it does more, for it explains the many points concerning compounds of the first order that they could not. And it is equally applicable to compounds of higher orders,—a field in which previous theories were scarcely able to make even a beginning.

According to the usual view, a salt of the first order is a compound in which the hydrogen of an acid has been partially or wholly replaced by a metal. A later modification corrects the definition to that of a compound resulting from the reaction of two or more compounds of the first order. Salts of the higher orders are compounds resulting from the union of two or more compounds of the first order. This latter class of salts forms the vast majority of chemical compounds. Of them the old valence theory gives only a vague idea. It was necessary that some one should first work out the constitution and construction of such compounds from available chemical facts and then deduce a suitable theory of valence to explain them. This Professor Werner has done. In studying his explanations of these compounds of the higher orders the applications of his theory to salts of the first order will become apparent without further discussion.

He divides the great class of compounds of the higher orders into two general divisions, calling the first "Anlagerungsverbindungen," that is, association compounds. To repeat what was stated a little above, it is a well understood fact that nearly all compounds of the first order (those of the type C_nH_{2n+2} being perhaps the only exception), unite with other first order compounds to form association compounds of the higher orders. As

a concrete example take the formation of sulphuric acid from sulphur trioxide and water. Now because sulphur is the strongest positive atom and oxygen the strongest negative atom the union must take place between these two so that we have as a simple structural formula by association $O_3S—OH_2$. This structure appears more complicated than the simple valence scheme of addition based on the bivalent nature of oxygen with the formula of $O_2S(OH)_2$. Yet is it not really more simple? Under the old scheme we had to assume the mobility of the hydrogen atom, a condition which seems rather improbable to say the least. Moreover, since there could be no tendency toward the formation of groups of the hydroxyl type in unions of compounds of the halogens and monavalent radicals in general, the valence theory had to explain these in a different manner. So while it claims that $SO_3+K_2O \rightarrow O_2S(OK)_2$, it had to explain the formation of chloro salts as $2KCl+PtCl_4 \rightarrow K_2PtCl_6$ or $2KCl.PtCl_4$. This latter coincides directly with Prof. Werner's theory. Now, from the valence theory we could expect no analogy between these two classes of compounds,—indeed, according to it none is possible. But from experiments we find that there actually is no difference in the stability and nature of the salts in general. From the old theory we would expect that the higher the oxide the larger the number of hydroxyl groups we could attach, but this is not substantiated by the facts. Four seems to be the limiting number of oxygen atoms in the majority of oxygen acids. Again water adds not only to oxides but also to halogen and similar compounds forming acids as in the formation of chloroauric acid $AuCl_3+H_2O \rightarrow Cl_3Au.OH_2$, altho it is evident that here the formation of (OH) groups is impossible. The logical conclusion is, that there is no difference in the manner in which these association compounds are formed, and sulphuric acid should be represented by a formula similar to that employed for chloroauric acid.

(*To be continued.*)

THE SEASONS—SUGGESTIONS FOR A LABORATORY STUDY.

By Joseph F. Morse,

Medill High School, Chicago.

The usual demonstration of seasons—with globe or tellurion—views the earth and sun from *space,* leaving the sun's course as seen from different latitudes to be determined by perplexing calculations as to the height of the noon sun and the direction of sunrise and sunset.

Yet it is the sun's course with reference to an observer's horizon that determines the seasons experienced at any latitude.

The following is suggested as a laboratory method of studying the sun *as viewed from the earth:*

The only materials required for this laboratory exercise are a 6-inch hand globe and a paste-board disc, about 1¼ inches in diameter, crossed by north-to-south and east-to-west lines—i. e. by two diameters at right angles to each other. The east and west points of disc, and the points on its circumference 23½° to the north and south of east and west, should be conspicuously marked by inking edge of disc at these points and by connecting the points by diameters drawn across disc. In preparing his disc the pupil may take points on the circumference one-fourth of the way from the east and west toward the north and south as a sufficiently close approximation to 23½°.

When pinned to globe the disc represents supposed observer's horizon circle—greatly exaggerated, of course. Observer is at foot of pin. The pin, if perpendicular to disc, is observer's vertical, and head of pin his zenith.

Suppose now the pupil wishes to determine the sun's sky-path as viewed from the *equator.* The following laboratory exercise may be used:

The Equator Sun-Paths.

Introductory:—The earth revolves around the sun with its axis always leaned 23½° to the north. Let your eye represent the sun. Keeping the globe's axis leaned 23½° to the north and the center of the globe on a level with your eye, hold the globe successively, at arm's length, to the west, south, east, and north of you. Notice that when the globe is east or west of the eye you can just see (shine upon) both poles. This is the equinox position of the earth to sun. When globe is south of you, the north pole leans toward the eye and the south pole from it 23½°. You can see

23½° beyond the north pole, and fail to see the south pole by the same number of degrees. This is the position of earth and sun at June solstice. At December solstice, when the earth is north of the sun, the south pole leans toward the eye and the north pole from it 23½°. As you move the globe from equinox to solstice positions one pole leans gradually toward the eye and the other from it at an equal rate.

Pin disc to globe's equator, with the north-to-south diameter in line with a meridian and the pin perpendicular to disc. Set the globe on a level surface, at arm's length from you, and bring your eye level with globe's center.

(1) *The Sun's Course at the equinox dates—Mar. 21 and Sept. 22.*

Place the globe in equinox position to your eye.

Starting with the disc on farther side of globe rotate the globe eastward (to the right) until disc is brought edgewise to the eye and you can just see the foot of the pin. It is now sunrise for observer at center of disc. A line from foot of pin to your eye is the direction of observer's sunrise, if read by the points of compass on disc. In what direction does observer look to see the sun rise?

Rotate globe to right until the meridian to which disc is pinned is between your eye and center of globe. It is noon for observer. The sun is crossing his meridian. A line from foot of pin to eye points at the noon sun. Where does the observer look to see the noon sun? How many degrees from his zenith is the sun?

Continue rotation of globe until disc is edgewise to eye in sunset position. Observer looks from center of disc to your eye to see the setting sun. In what direction does the equinox sun set as seen from the equator?

Imagining yourself to be on the equator Mar. 21, or Sep. 22, point successively in the direction of sunrise, the noon sun, and sunset.

How long is the day on Mar. 21 at the equator? To answer this count the meridian spaces that pass between your eye and center of globe while you rotate it from sunrise to sunset positions of disc.

About when would the equinox sun rise and set at the equator? How do you know?

(2) *The Sun's Course at the June solstice—June 21.*

Place the poles of globe in right position to your eye for the June solstice.

In the same way as before rotate the globe from sunrise to sunset positions of disc, and note the direction of sunrise, the noon sun, and sunset, and count the meridians passing your eye to find the length of day.

Does the sun rise north or south of east? How many degrees? Does observer look north or south of the zenith to see the noon sun? About how many degrees? Where does the sun set? How long is observer's day?

Imagining yourself at the equator on June 21, point in the direction of sunrise, the noon sun, and sunset.

(3) *The Sun's Course at the December solstice—Dec. 22.*

Place the globe in right position for the December solstice.

Determine as before the directions of sunrise, noon sun, and sunset, and the length of day.

Imagining yourself on the equator December 22, follow with your finger the course of the sun from sunrise to sunset.

Judging from the sun's path at different times of the year, describe the heat seasons of the equator.

Why is it always pretty warm at the equator? Is it equally warm the year through? If not, at what times of the year is it warmest? Why? When is it coolest? Why? Is the difference between the cooler and warmer times much or little? Explain.

Draw a temperature curve to represent to the eye the equator heat seasons—as follows:

Draw a horizontal line of any convenient length to represent a years' time, from December solstice to December solstice. The level of this line can represent the average temperature at the equator—neither the warmest nor the coolest. Divide the line into 4 equal parts by short perpendicular lines extending equally above and below the horizontal line. The middle perpendicular fixes the June solstice date. Write June 21 above it. Above the 2 equinox perpendiculars write the proper dates. At each of the solstice and equinox dates make a dot either on the horizontal line or above or below it according as you think the temperature at that time of the year is average temperature or above or below the average. How far you place the dots above or below the horizontal line depends upon how much warmer or cooler than the average you think it is at that time of the year. Beginning at the left draw a line connecting the five dots (five, because December solstice occurs twice—at beginning and end of the year line). This temperature line should have no sharp turns in it because

the sun's path and the resulting temperature do not change suddenly. Where the line changes its direction it should do so by a curve. This is why such a temperature line is called a temperature "curve."

Does your equator temperature curve show one, or two, temperature hills (warmer times), and one, or two, temperature valleys (cooler times)? At what dates does the curve reach the highest and lowest points? Why? Should the hill, or hills, be high, or low? Why?

To sum up the results of your study of the heat seasons at the equator, imagine yourself to have spent a year—from Christmas to Christmas—visiting a friend living at Equatorville on the Kongo. Describe briefly the temperature changes you experienced, first, in the course of a day, and then, during the year. Account for the changes by reference to the sun's path.

A PHYSICS COURSE FOR GIRLS.*

By W. G. Whitman.

Ethical Culture High School, New York City.

In spite of the fact that it is usually the pick of the class who offer themselves as candidates for college, in the last four years only one-half of the candidates in physics at the Board examinations have passed with a grade of 60%. This is often cited as evidence of poor teaching in the high school, but I contend that it is due to the fact that many teachers have already abandoned the practice of cramming pupils for examinations and are enriching the course with things of vital interest.

College preparatory physics has developed from a study which was chiefly a discussion and reasoning upon natural phenomena to a subject which is rigidly mathematical; from a subject of qualitative observations to one of exact measurements. The teaching of exact quantitative measurement in secondary schools, to give the pupil habits of accuracy and carefulness, is almost a failure.

A girl's world differs, in many ways, from a boy's. He brings to the physics class a fund of information, obtained from his world, which makes a large part of physics a real live subject to him. The girl has had some of the same experiences, but her

*Abstract of paper read before Physics Club of New York, Dec. 5th, 1908.

world is smaller; she has had less opportunity to observe the commercial physical devices. She is less likely, in future years, to be called upon to run an automobile or a dynamo, than a boy is; and she, naturally, does not feel quite the interest of a boy in studying the mechanism of an automobile or the operation of a dynamo. The boy's mind is receiving constant stimulus from applications of physics, which fail to bring forth any activity in the mind of the girl.

Pupils with different aims, different abilities and different qualifications present themselves for a study of physics. What can be more absurd than to expect them all to profit from identical treatment of the subject. There should be, in part, a different selection of topics and there should be a different treatment of the other topics for different groups of pupils.

For the average girl, it would be better to cut down the time devoted to mechanics and increase the time given to heat. To indicate more clearly the kind of work, which it seems to me, would be of value to girls, I will roughly outline the subject of heat. This is not a final outline, but a suggested list of topics and the kind of experimental work to be made prominent in the study of heat.

Early and present theories of heat.

The sun, the great source of heat. Distribution of heat on the earth. Effects.

Other sources of heat. Heat of oxidation; combustion; kindling point.

Fuels in common use. Devices for burning different fuels; how used.

Pupils make comparative tests of kerosene, denatured alcohol and gas for heating a single room; consider heat produced, cost, gaseous products, moisture and carbon dioxide which are added to the air of the room.

Radiation; effect of kind of surface upon radiation and absorption of heat.

Conductivity of materials; applied to clothing for summer and for winter wear; various uses of non-conductors; fireless cookers, thermos bottles, double windows for winter.

Expansion; combined effect of expansion and non-conductivity upon a brittle substance, illustrated by the sudden heating or cooling of glass.

Relative volumes of the same weight of ice, water and steam; explaining the bursting of water pipes and pitchers of water by freezing, etc.

Boiling temperature of liquid depends upon pressure; increased by addition of salt. Pupils may prepare condensed milk or evaporated cream by evaporation of milk under reduced pressure.

Absorption of heat by freezing mixtures; determine how low a temperature may be produced by various mixtures.

Distillation; fractional distillation; different fractions obtained from crude oil; uses of these different products.

Melting point, vaporization point and flash point of lard. Dangers from using heat or flame near volatile liquids. How to extinguish fires.

Refrigeration and cold storage. How low temperatures are obtained. Value of low temperatures. Special study of the household refrigerator; considering amount of ice melted per day, heat absorbed, temperature of the refrigerator; does temperature vary when ice gets low? Melting point of butter; possibly determine the specific heat of some foods and find amount of heat they lose when cooled from room temperature to refrigerator temperature. The value of keeping food at a low temperature; illustrated by tests upon milk. Determine the acidity of milk kept at room temperature for 24 hours and of milk kept in refrigerator same time.

Use of heat for sterilizing, pasteurizing; canning fruit, etc.

Hot air, hot water and steam heating; fireplaces. Hot water supply. Ventilation.

Dew point and relative humidity. Clouds, fog, frost, snow. Relation of storms to atmospheric pressure. How climate is modified by large bodies of water. Relation of change of climate in geological history, to cooling.

General idea of heat for power. Hot air, gas, gasoline and steam engines.

The other divisions of physics, I would make less complete, but let the same idea guide in the selection of topics. Many of the girls in my classes, I must confess, have usually found the experiment of determining the acceleration due to gravity an uninteresting and irksome task; I decided not to repeat it this year, but instead to study about Galileo and his experiments upon gravity and acceleration. You may imagine my surprise, when one day, the girls asked if they might not be allowed to repeat Galileo's experiment to determine the acceleration due to gravity. They had acquired interest by this historical sketch. They did the experiment and although they are not apt in mathematics, they carried out the calculations with less trouble than any class I have ever had before. I believe it was the momentum of interest which overcame the friction and carried them through. This incident only goes to strengthen my belief that if we cannot enlist the interest of the girl in a subject we better not try to teach it.

I believe that a course in physics for girls should; enlist the interest of the girl; show the growth of the science, by a study of its historical development; inspire a regard for those who have developed the science and for the wonderful works they have accomplished; give information in regard to common and useful facts of the science; enable the girl to understand some of the common physical devices; prepare her to interpret the natural world about her, and thus add to her life of usefulness and happiness.

A SIMPLE VAPOR PRESSURE APPARATUS.

By E. J. Rendtorff.

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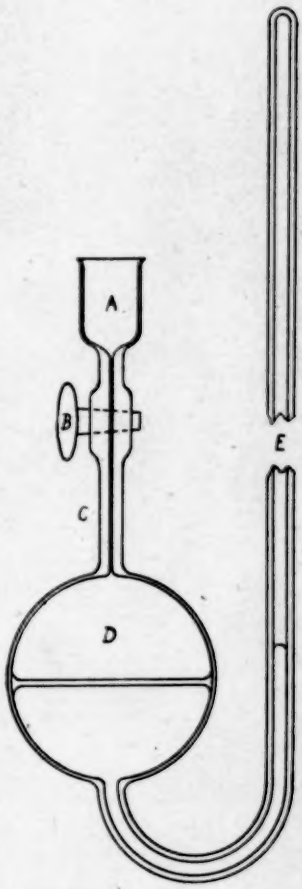
A highly desirable experiment in the physical laboratory is the determination of the vapor pressure of various liquids at different temperatures. This experiment is not given in the numerous secondary school manuals and consequently no satisfactory apparatus for this purpose is sold by our various supply houses. In Prof. Millikan's book, Mechanics, Molecular Physics and Heat, a simple form of apparatus for this determination is described, but it has the disadvantage of being non-transportable when filled.



The accompanying illustration presents a similar type of apparatus that is transportable and can readily be filled with any liquid whose vapor pressure is to be studied. To a bulb D, about 6 cm. in diameter, is attached a graduated tube E some 85 cm. long and 4 mm. internal diameter. Above the bulb is attached a stop cock B and a small cup A.

The tube C, of small internal diameter, is sufficiently long to prevent the stop cock from coming in contact with the water in which the bulb is immersed.

To fill the apparatus open the stop cock, attach a Geryk air pump and exhaust the bulb thoroughly. Close the stop cock and fill the cup, A, with clean mercury. Allow nearly all of this to enter the bulb. Refill the cup and allow the mercury to run into the bulb until the latter is from one-third to one-half full. Incline the apparatus, allowing the mercury to completely fill the long tube. On erecting the apparatus the mercury in E will stand at the same, or a slightly lower level (due to capillarity), than in the bulb.

Now allow a few cc. of the liquid, whose vapor pressure is desired, to enter the bulb. Totally immerse the bulb in a pail of water, stir constantly, and take the vapor pressure for every increment of 5° C. Plot the curve.

The water in the bulb can now be removed by evaporation under diminished pressure and other liquids introduced.

When the barometer pressure is low, and the boiling point of water consequently below 100° C, a handful of some salt can be dissolved in the water, to increase the temperature of ebullition. In case the glass tube is not graduated the vapor pressure readings can be taken with an ordinary meter stick. Where previous determinations had been made of the relation between boiling point and pressure it will at once become apparent that a liquid boils when its vapor pressure equals the external atmospheric pressure.

When the apparatus was first designed it was feared that leakage of air at the stop cock, due to the expansion of the glass, might seriously interfere with the results of the experiment, but after a test of several weeks no appreciable leakage could be detected. The stop cock was, of course, first coated with a good grade of vacuum wax.

On opening the stop cock a regular barometer results, which can be used during that part of the year when heat is not being studied in the laboratory.

WHY BODE'S LAW?

Some five years ago while considering the "dark lanes" in the photograph of a nebula this answer came to me. After the formation of the first planet from the outer part of the nebula, it becomes a perturbing force tending to cause the formation of another planet "a little over ½ way out to it".

For if the "dark lanes" are openings similar to those between the rings of Saturn and from a like cause, Kepler's third law gives,

$$\frac{x^3}{1^3} = \frac{1^2}{2^2}, \quad \frac{g^2}{1^3} = \frac{1^3}{3^2},: \text{ (to two places)},$$

we have for the distances from center of nebula to the two "lanes" having the greatest tendency to forms .63 and .48. If the ring between these lanes forms a planet it would be "a little over ½ way out to 1st" and would become the chief cause of the formation of the next "a little over ½ way out to it", and so on. T. M. BLAKSLEE, Ames, Iowa.

The foregoing will be of interest to those who still hold the view that planetary systems have their origin in a cooling and shrinking nebular mass.—M. Ed.

PHYSICS AS A PEDAGOGICAL SUBJECT.

II. Generalizations and Classifications.

By J. Harry Clo.

A thorough mastery of the subject of elementary physics as well as the derivation from it of the greatest permanent benefits, requires that the student must not only understand each individual part thoroughly but that he must see each part in its relation to all other parts. A ready mastery of the subject requires that he be compelled to learn only a few fundamental things from which his reasoning powers can evolve the others or to which these others may be referred. In other words he must build his conceptions and base his study upon a few definite closely related principles; no fact must remain isolated and no specific principle must be new. Both of these requirements are well-nigh impossible to fulfill in our modern physics, but even under the present conditions it seems to the writer that much can be done to improve it.

As soon as the beginning student of physics has become somewhat accustomed to the intricacies of its methods of study he discovers that, as in the case of most branches of study, there are many things to learn, not merely that there are many facts, for that is true of all study, but that he must apparently learn a new principle for almost every new fact. If he is fortunate enough to understand the new matter that is presented to him, he so often finds difficulty in discovering the relation which this new matter bears to that which he already knows.

Naturally the teacher attempts to bring as much as possible under each general principle, and to show as close relations as possible between different facts and phenomena. This, however, is difficult and in the success of the effort the subject falls short of what should be the condition in order to bring it within the grasp of the average pupil. Whether the fault lies in the teacher or whether it is in the subject, in spite of the best results, the student is constrained to believe that in mastering a certain part of physics he must study more material than would be necessary in the mastery of an equal amount of any other science. And such is actually the case. If five years of study in each science were taken as a unit, the student of physics would be compelled during the first year to learn many more apparently distinct principles and terms than in any of the other sciences, and in the

following four years he would spend more time in discovering that he had learned only a few general principles and the facts which logically follow them. This difference between physics and the other sciences is due to the fact that the generalizations and classifications in the former are inadequate to compensate for the great variety and scope of the subject matter included in it. It is no doubt true that its general principles or laws are numerically as plentiful as those of the other branches of study but neither do they cover the field as thoroughly nor treat special cases as unerringly. In mathematics there are generally a few specific principles, some of which follow from preceding studies as those of algebra, and others that are assumed fundamentally, as the axioms of geometry, and to these the student has recourse in the special cases which confront him. In elementary chemistry a large part of the subject follows from a few classifications and the laws of proportions, and how much more definite and useful are these than corresponding ones in physics. In the biological sciences the general laws are largely supplanted by interesting and instructive classifications, the very essence of order and system. In all of these branches a law or principle once fixed from special cases can be used almost universally throughout the subject. Hence there is a necessity for a few definite, far-reaching principles only.

At first thought it may seem strange that physics, a subject founded upon the study of natural laws and their applications, is defective in this respect. But the study of laws has largely given place to the discovery of laws, for physics has undergone much change since natural philosophy first flourished. It has changed from a study that was largely subjective and observational to one that is largely objective and experimental. It has changed from a "philosophy" to a "science" and as such it must reach the student from a strictly exterior or objective source. Hence in elementary physics we no longer devote ourselves to a study of what ought to be true but seek rather for what is true, and in learning the scattered facts we too often fail to carry the study far enough to classify our new knowledge. It was not difficult to avoid confusion as long as a law or principle was assumed hypothetically or upon the works of some past master. and the subject was confined to a study of the phenomena or principles covered by that law or its corollaries. But in our present physics this is not done, and in the change that has

taken place we have been left with a branch of study whose contents are not fixed by any natural order or sequence; but we are given a number of different subjects to study and are expected to arrange and classify them as best we can. Many of the concepts, methods of presentation, arrangements, etc., that we have, are left over from the "natural philosophy." They were intended to apply when the subject was handled from the deductive side, when the more advanced methods of mathematical analysis were attempted in elementary work. Hence when we begin studying from the inductive standpoint they do not always fit. In the former methods generalizations were a part of the treatment or system, and classifications were almost superfluous. In our present treatments neither of these aids to science teaching seem to be applied to any great extent.

That the subject matter of physics is not brought more completely under a few general laws or principles is due largely to the great variety of matter that goes to make up our modern physics and so long as the subject presents the variety of study and covers the different fields that it now does this will be difficult to accomplish. No other science presents such a range of study from planets, masses, molecules down to atoms and then away into the "ethereal" hypotheses of corpuscles and electrons. Other sciences have seen fit to omit, at least in their elements, the treatment of things so thoroughly incompatible, but physics fosters them all. Furthermore, this dissimilarity of subject matter is not the only difficulty encountered in the successful teaching of elementary physics. An attempt to use the methods of classification, etc., reveals the fact that the study of the different subjects does not always begin in the same manner or at the same stage, or is it always carried to the same limit. Following the natural historical method, the study of each subdivision begins at the point where scientists first began to develop it and continues until a certain fraction of all known facts is included. Since each subdivision originated differently, it must be studied differently, and because of unequal development, its study may be carried to any extent. For instance, in mechanics the first conceptions are very familiar; in sound, heat and light they become more and more difficult, until in electricity they become almost impossible. In sound, heat and light, the origin may well be considered first, but who would begin the study of electricity by explaining its origin?

Among the most valuable improvements in present methods of teaching physics is a most welcome tendency to present the subject from a standpoint of energy and its transformations, but it is safe to say that few pupils learn the real energy relations illustrated in almost every phenomenon. Few are taught, for example, that all machines are merely transformers or transferrers of energy or both, but many learn that a telephone is a distinct instrument for transmitting sound and a dynamo is a machine for "producing" electricity, leaving future study the opportunity of disclosing the fact that they are only modifications of the same thing. While much can be included under the principles of work and energy much more is to be taught in our present courses than can be brought under its applications in an elementary way. With the law of conservation of energy we can teach many facts of mechanics and a few of sound and heat but little do we find in it that will explain such phenomena as the reflection or refraction of light. A like failure of application may be seen in many of the other general principles. In the laws of motion and the study of forces we find little place for such conceptions as electric current and electromotive force, a thing which the average pupil is justified in expecting. In elementary physics there is a hazy expanse between Hooke's law and a wave motion of light, and who can satisfy the natural longing of the pupil to find in Boyle's Law a corollary to Hooke's?

Some of these apparent inconsistencies are slowly being eradicated in our more recent text-books, but developments in the field of pedagogical physics are not bringing forth new relations, analogies, etc., as rapidly as new matter is being added to the science. With the advent of new material and the new and more complete explanations of older phenomena the forms, conceptions and treatments of physical principles are not advancing to meet the new conditions. The older treatment of the subject was in many respects far from simple and logical, and the addition of new material without a natural place in the scheme of the science into which this new material could be fitted, has made the recent methods of treatment less logical than before.

For these reasons, the older and more fully developed parts of the subject are the most difficult. The following may be cited as some of the common treatments which have been handed down to us for generations and which are now embodied in most

of our modern text-books. For example, we are taught various laws of resolution of forces, velocities, etc., all as distinct cases, instead of a general law that contemporary causes have the same ultimate effect as successive causes. We are taught a conception of inertia, one of force, another of moment of force, and then are taught that moment of inertia is a value expressed by summation mr^2. We are still taught that liquids rise in capillary tubes when they wet them and are depressed when they do not, and later we may fortunately learn that liquids rise in tubes and wet them both for the same reason. One formula teaches us the relation of pressure in a liquid to area, depth and density; another, the relation between the pressure indicated by a barometer and the height, area and density, while a still more general but apparently entirely distinct law teaches us that the pressure of a liquid is equal to the weight of the highest column above the point of pressure and that it is transmitted equally in all directions. Almost innumerable are the applications of these general laws if they were but interpreted with respect to the special cases.

At first thought it may appear that an improvement of this condition might be effected by the use of the deductive method, i. e., by assuming or proving mathematically some of the general principles and applying them to special cases. This might prove a good method for a review of the subject, but its feasibility for beginning students is doubtful. It is not the intention of the writer to suggest such a solution. If the purpose of physics is to introduce the scientific method, to establish relationships between the pupil and external phenomena, or to train the student in establishing these relationships, then the inductive method is necessary. Also, if the student is expected to understand and preserve a knowledge of the relations which physical phenomena bear to each other, some deductive study is necessary. Hence it seems evident that teachers are thoroughly justified in using both, but that the difficulty lies in the fact that in the usual treatment, the study of relations inductively is not carried to a definite and logical conclusion, and the general laws resulting from that study are not applied in a complete survey of the field of physics.

PROJECTION DEMONSTRATIONS TO ACCOMPANY LECTURES ON WAVE MOTION.

By Will C. Baker,

School of Mining, Queen's University, Kingston, Ont.

As the curvature method of dealing with wave transformation has secured a place in many of our best elementary text-books on physics, it may be well to point out that all the more important of these phenomena may be easily demonstrated to classes of any size by a simple projection method. The arrangements herein described enable the changes in the curvature of waves to be observed by projecting "shadows" of actual waves onto a screen. The method has been used by the writer since 1898 and has been the subject of notes in the *Physical Review* (March, 1900), and in the *Physikalische Zeitschrift* (December 22, 1900). It is thought well, now, to describe it in its latest form with the changes that experience has suggested.

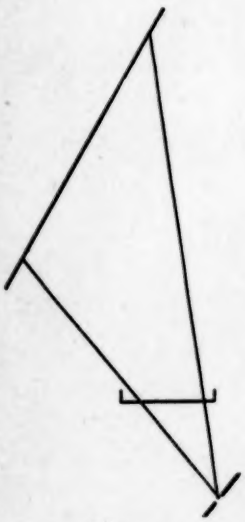


Fig. 1.

The apparatus consists, first, of a shallow water-tight box (12 in. by 20 in.) with wooden sides and a plane glass bottom—a bit of thick plate glass preferred—and, second, of a few simple accessories such as straight bars of lead, bent strips of galvanized iron, and some simple "forms" cut from window glass. In use the box is supported over a bare arc, with the positive carbon below, so placed as to throw the shadow of the box onto the screen. It is best to have the screen inclined as in Fig. 1, but either a vertical or horizontal one (e. g., the ceiling) may be used. In the absence of an arc the projections may be made with a coal oil lamp and mirror (see Fig. 2). The first operation is to adjust the box so that its bottom shall be accurately level—any marked departure from the horizontal produces a non-uniform propagation of the waves. Water is now poured into the box to a depth of six or seven millimeters and as soon as it has settled down to comparative rest, the projection through the liquid shows a uniformly bright area on the

screen. If now a wave of any form be set up, the refraction of the light from the arc in passing through the water throws "shadows" on the screen corresponding to the wave front. For instance, if the water surface be touched with the finger or with a pencil point, a circular wave is set up which is seen on the screen as a circular shadow of uniformly increasing radius advancing to the sides of the box. These waves travel quite slowly and any changes in their forms are easily followed. If a straight bar, say a piece of lath, be set edgewise into the water or removed from it, an approximately straight wave front advances at right angles to it in both directions.

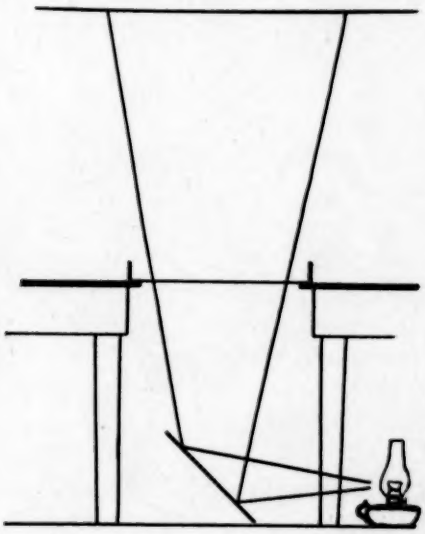


Fig. 2.

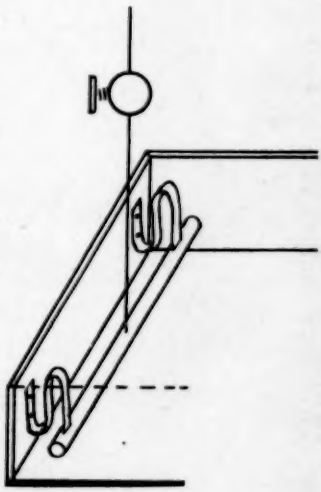


Fig. 3.

In the writer's box is a device for starting a train of straight waves. This consists merely of a straight bar nearly as wide as the trough, held parallel to the shorter edge by S shaped springs, as shown in Fig. 3. From the middle of the bar a wire passes upwards and on this is a movable mass and set screw adjusted at such a height as to give the system a period of two or three vibrations per second. A *slight touch* will cause a vibration that sends a train of equidistant parallel straight waves across the screen. It is necessary to caution users against any large vibration in this case as a violent disturbance is so complicated as to present no visible relation to a straight wave. When not

in use for trains of waves it is advisable to block the wire into a fixed position with a piece of wood between it and the box edge. This is to prevent it vibrating with accidental touches.

The first demonstration in the usual course, is to show that the waves in their progression do not carry the medium forward with them. To do this a region of water is colored by introducing from a dropper about a tenth of a cubic centimeter of ink. On causing a train of waves to pass over the inky portion the class can see that the colored water is not carried onward by the waves. The same remark applies to small chips floating on the water surface.

Next one usually calls attention to the spherical waves obtained in a homogeneous medium and illustrates the remarks with circular waves on the screen. In most cases it is best to use *single* waves and not trains of waves as it is easier to concentrate the attention of an audience on the transformation of *a single wave at a time*. Attention is now directed to plane waves as parts of spherical ones of large radius and one or two straight waves are sent across the screen. It is well to use these last two points as introductory, for it secures that the class, having seen the meaning of the moving shadows in these simple cases, will the more readily interpret them in more complicated cases.

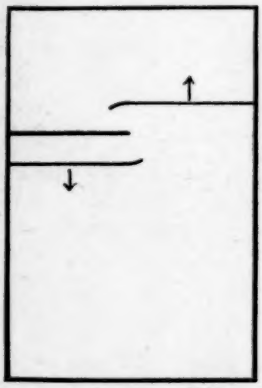


Fig. 4.

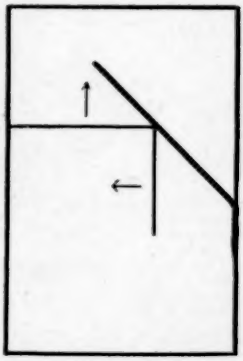


Fig. 5.

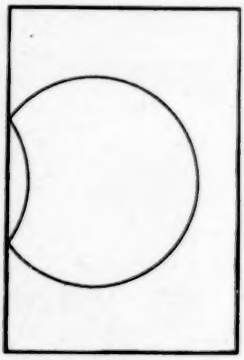


Fig. 6.

In dealing with the phenomena of reflection, it is found best to begin with a case of normal incidence, as follows: A leaden bar is placed partly across the field as in Fig. 4 and a single plane wave is sent against it. Both the undisturbed and

the reflected parts of the wave are clearly visible traveling in opposite directions with equal speeds. (See Fig. where the arrows give the direction of motion of the wave fronts.) When the reflector is set at an angle (best at 45°) the change in the wave front appears as in Fig. 5. Reflection of circular waves is shown against the side of the trough (see Fig. 6) and ideas regarding the image are introduced. Reflection from curved surfaces is demonstrated by employing strips of galvanized iron bent to the required shape. A single plane wave sent into a concave arc is seen after the reflection as a circular wave converging to the focus and then diverging therefrom. A circular wave set up at the focus may be observed to leave the reflector as a plane wave. Both the curved and straight parts are clearly visible (see Fig. 7). Conjugate foci of course follow in the same way, also images in concave reflectors. Reflectors of different curvature may be produced either by further bending the strip of metal used above, or by employing different strips. Reversing the strip so as to present the convex side to the waves enable one to show the phenomena of convex reflectors. The dissipation of energy at reflection may be shown by simply starting a circular wave and watching it die out after successive reflections at the sides of the trough.

All these phenomena are strikingly distinct if attention is given to having the trough quite level, as any tilt causes differences of depth with corresponding variations in the speed of the waves.

The velocity of a wave is of course dependent on the depth of the water so we can easily show refraction effects by producing shoal places in the tank. This is best done by cutting window glass to the forms required and mounting these on three or four legs cemented with sealing wax. If small strips of glass be cut, say 1 cm. by 5 mm., two or three of these mounted one on top of another make a good leg that raises the upper surface of the glass "form" 5 or 6 mm. above the bottom of the box. To make the sealing wax hold it is of course necessary to gently heat the glass (in an oven) until the wax will melt on its surface. While it is still warm it is well to smear the wax *all around the lower edge of the form* so as to leave a strip about 5 mm. wide that will throw a shadow on the screen. This is necessary in order that the class may see distinctly just where the shoal begins. The glass shoals must be quite clean so that

they will wet easily with a shallow layer of water, and the water surface must be adjusted so that it is about 1 mm. deep over the upper surface of the shoal. A broad camel's hair brush is most convenient for spreading the water over the shoal, as capillarity generally prevents it flowing over by its own force.

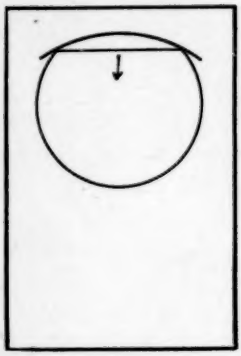


Fig. 7.

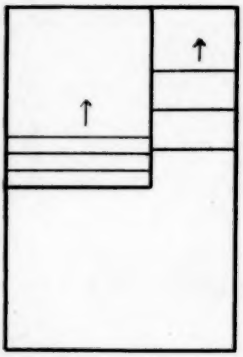


Fig. 8.

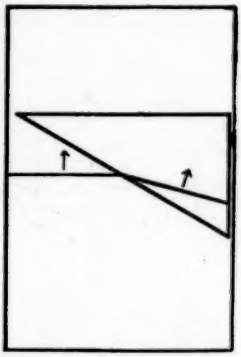


Fig. 9.

It is best here also to commence with normal incidence. A single plane wave is sent onto a rectangular shoal (see Fig. 8) and the retarded and unretarded portions of the wave are visible at the same time. The idea of the index as being the ratio of the velocities in the two media should be now introduced. If *a train of waves* be sent onto the shoal the shortening of the wave length is easily seen. Refraction at other incidences is shown by triangular shoals as in Figs. 9 and 10; the first being the refraction in passing into a region of smaller propagation

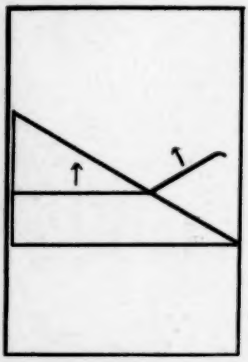


Fig. 10.

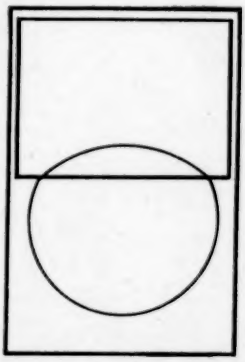


Fig. 11.

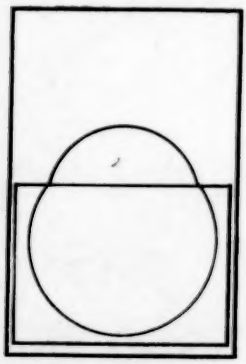


Fig. 12.

velocity, and the latter the converse. In the second case there is no change of direction in passing *onto* the shoal as the incidence is normal, and attention may be centered on the change in leaving this region. Refraction of circular waves in both of these cases are given as in Figs. 11 and 12, where the disturbance is started by simply touching the water surface with the finger over the deeper part, and over the shoal respectively. The changes in curvature are evident.

The case of the double bending by a prism is shown as in Fig. 13 where the lines *a b c* represent short leaden stops to prevent diffraction effects from obscuring the phenomenon. *Under good conditions one may even show total reflection at the base of the prism.* Principal and conjugate foci of lenses are shown with lenticular shoals as in Fig. 14 used with stops at the corners as in the case of the prism.

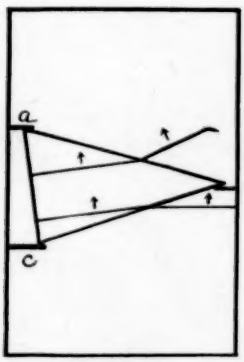


Fig. 13.

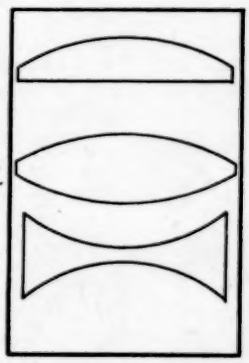


Fig. 14.

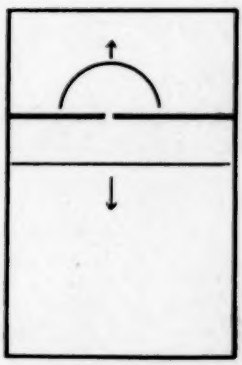


Fig. 15.

The analysis of a wave into component wavelets may be suggested as follows: Two barriers of lead are set across the trough leaving only a small opening near the middle Fig. 15. A plane wave sent against this is reflected except at the gap where a circular wavelet proceeds into the space beyond. If two or more gaps be left, one sees a series of these partial waves, and if one use nine or ten, say a centimeter apart, they may be seen to build up again into an approximately plane wave. It is easier though, to make a "comb" by driving a dozen inch nails one centimeter apart into the edge of a piece of lath, so that the heads lie in a straight line. If this be dipped into the water, a dozen circular waves are set up, which, in proceeding across

the screen, build up into a very good plane wave. This is particularly instructive as both the elementary and resulting waves are clearly seen.

A simple case of diffraction is obtained by sending the waves against a barrier that extends two thirds of the way across the trough. A plane wave sent against this shows diffraction at the edges after passing the bar (see Fig. 4).

The great beauty of the phenomena referred to delights all classes, and the simplicity with which these results may be attained must appeal to all teachers of the subject. The whole secret of success lies in having the apparatus level, the surfaces clean, and the water not too deep over the shoals. These conditions being secured one must use only single waves (wherever possible) to have complete success.

In conclusion I wish to acknowledge my indebtedness to my brother, H. S. Baker, B.Sc., for suggesting the spring vibrator and for certain other details in the development of the method.

SYMPOSIUM ON THE PURPOSE AND ORGANIZATION OF PHYSICS TEACHING IN SECONDARY SCHOOLS.

(*Continued from January, 1909.*)

The Aims and Needs of High School Physics.

XI. By Professor R. A. Millikan,

The University of Chicago.

The fundamental purposes of a high school course in physics are so interlinked with the purposes of all public education that it seems to me impossible to discuss the smaller topic save in its relations to the larger.

If then I were asked to state as briefly and as broadly as possible the fundamental aim of all public education I should say that it was *to give to the rising generation the best possible preparation for perpetuating and improving upon the civilization which it inherits.*

If I were asked to enumerate, in order of importance, the factors which contribute best to this end I should say:

1. The development in the young of *high ethical standards and ideals;* for education without moral character is obviously one of society's greatest menaces.

2. The development of the power of *self-control* as it manifests itself especially in *industry and application to the mastery of difficult situations;* for without this quality success in any walk of life is, broadly speaking, impossible.

3. The implanting in the rising generation of *a knowledge of, and an ability to use,* the materials and the tools by means of which existing civilization has been built up; for a knowledge of fact and a mastery of methods unknown to the unlearned is the most tangible and the most obvious sign of education.

Taking these three statements as a preamble let us consider in what way our present high school curriculum, and in particular our present courses in physics subserve these ends, the first ethical, the second disciplinary, and the third utilitarian, and how they may be made to subserve them better.

The first and most important of the three is not and probably cannot be, officially recognized in the organization of our public school system. It is left to each individual teacher, and herein lies his incomparable opportunity, to pass on the best ideals of the past to the generation which is to follow. This can be done in connection with all studies, but physics offers especial opportunities for impressing the lesson of scrupulous honesty in observation and statement, and for inculcating habits of accuracy, reliability, conciseness and orderliness.

The first need then of high school physics, as of all teaching, is not new methods or new books, but rather the right sort of teachers—men who realize that the greatest need of the schools is, in the words of the resolution adopted unanimously by the National Educational Association last summer, an ever "increasing appreciation among educators that the building of character is the real aim of the schools and the ultimate reason for the expenditure of millions for their maintenance," and that "the tendency in the minds of the children and youth of to-day toward a weak appreciation of the demands of duty, and a disposition to follow pleasure and interest rather than obligation and order," constitutes a "condition which demands the earliest thought and action of our leaders of opinion, and places important obligations upon school boards, superintendents, and teachers."

The second aim, namely, the disciplinary one, may, and of course should, enter into all of the courses in the curriculum, and yet different subjects obviously have widely different values when regarded as means of giving the student control over dif-

ferent faculties, and it will generally be conceded that physics is of peculiar value in developing and disciplining the *reasoning* faculty. In it the *problem method*—a method which has no equal in developing the powers of the student—is particularly easy to apply. In it the memorizing, text-book habit, to which the pupil is so diligently trained in many other studies, is particularly easy to eradicate. For physics is unlike most of the other subjects of the high school course in that the material with which it deals is almost wholly available to the student *at first hand,* so that in it he can be taught to observe, and to begin to interpret *for himself* the world in which he lives, instead of merely memorizing text-book facts, and someone else's formulations of so-called laws. Indeed, from the intellectual standpoint, the main object of the course in physics is to teach the student to *begin to think for himself,* to begin to construct for himself with the aid of the great generalizations and hypotheses which have come down from the past, an orderly world out of the chaotic jumble of phenomena which observation presents to him. The old memorizing method of teaching physics is by far the easier one, but a physics from which all the difficulties have been removed is a false, and a useless physics. Whether the difficulties are removed by the old method of teaching merely by authority, the memory being crammed with undigested facts. laws and formulas, or by the more modern method of omitting everything bothersome, and serving up to the pupils delectable dishes of predigested thought, the *result* is the same—an *emasculated* physics, entertaining, no doubt, in the latter case, and very dry and uninteresting in the former, but well-nigh valueless in both. I have all sympathy with every effort to make high school physics more interesting *by making it more intelligible* and I cordially admit that much that has been taught in the name of high school physics within the past decade has come over from college physics and has been completely unintelligible to beginning pupils, but let us beware that in the effort to make physics popular we do not confuse *instruction* with *amusement,* the *interest of achievement and mastery* with the *interest of entertainment,* the *satisfactions of the student* with the *satisfactions of the vaudeville patron.* In the concrete, let us beware that we do not replace a study of naked, fundamental physical principles in the light of well chosen laboratory and class room exercises, by a childish playing with some new physical toys.

It is not teaching physics, nor developing the intellectual powers of the student in any way, merely to show him what levers to turn and what buttons to push to make a toy steam engine go, an automobile start, or a wireless telegraph work. There are thousands of firemen, chauffeurs, and amateur electricians so-called, who have learned the routine of running machines like these, but who yet have little or no conception of the physical principles underlying them. The case of the boy who knew all about installing an electric bell, but thought it was rung "by the vibrations of the electric current" illustrates well the deplorable consequences of the failure to present simple demonstrations which give insight into the fundamental principles underlying physical appliances.

I do not for a moment mean to deprecate the study of the applications of physics to modern life. That is a thing of the utmost importance, as soon as, but not before, the pupil has had such an introduction to underlying principles through simple, definite class room and laboratory demonstrations that he is able to see how these principles find application in the machine under consideration. In other words, in a beginning course the pupil should not only be led *from the concrete to the abstract,* as he is led whenever the discussion of any topic is centered about definite class room or laboratory experiments, but he should also be led *from the simple to the complex.* The inversion of this order almost invariably results, as I think well nigh all physics teachers of experience will bear witness, in replacing the pupil's intellectual interest in the problem of understanding the machine, by a mere entertainment at seeing its wheels go around. I know of no more enervating influence in present day education than this.

From the disciplinary standpoint, then, the greatest need of high school physics to-day is the kind of teaching which actually starts the pupil in the habit of independent thinking—which actually gets him to attempting to *relate;* that is, to *explain* phenomena in the light of the fundamental hypotheses and theories of physics. As a means to this end we need more and better *direct experimenting* and discussing of experiments in both class room and laboratory, a less *slavish use* of the text-book (not, however, less use of it), a larger use of the *problem method* in its broad sense, not in its narrow sense of obtaining numerical

results by substituting more or less intelligently, generally less, in the formulas of physics.

When we turn to the third aim, namely, that of developing in the student the ability to understand and to meet the situations of modern life, we shall have difficulty in finding any subject in the high school curriculum which can lay claim even to equality with physics. For, in its externals at least, our present day civilization differs from the best civilization of the past, that of Greece, chiefly in its application to the modern knowledge of physics and chemistry to the problems of human life. We may go still further and say that even in the realms of the intellect and the spirit one of the most conspicuous differences between the modern and the ancient world lies in the fact that the method by which results have been reached and progress made in physics, chemistry and biology has gradually been pushed over into all branches of study. The "modern method" and the "scientific method" of approach to all problems are almost identical terms. The essential characteristics of the method are: (1) The dispassionate, unprejudiced, painstaking observation of facts and phenomena; (2) The setting up of a working hypothesis to correlate the observed facts; (3) The readiness to modify or abandon altogether this hypothesis, as soon as, in the light of further facts, it is found to be less well adapted to the correlation of the existing data than some other hypothesis which we are able to frame.

With reference, then, to the third aim, the chief need of the course in physics is the sort of teaching which gives to the pupil not only a knowledge of and an ability to apply a few of the most fundamental principles of physics, but which *opens his eyes to the method of physics,* which gives him the *scientific attitude* toward the world, which helps him to appreciate the *nature of evidence,* and the hypothetical character of all our great generalizations. This can be done by giving to physics incidentally perhaps, but none the less truly, some sort of historical setting—by showing the pupil how and when they have been modified, and, in some cases, discarded altogether, as science has grown. I can conceive of no better way of showing a boy the folly of cock-sureness, and of implanting in him the seeds, at least, of the scientific attitude toward all the relation of life, than by giving him a glimpse of how Galileo, and Newton, and Volta and

Franklin, and Faraday, and Maxwell, and Henry, and Helmholtz, and Thomson, and the other great makers of physics have themselves worked.

Finally, every good first course in physics must, in my judgment, be a fairly extended *survey course*. It should be *thorough* in the sense that principles of the *first* order, not those of the second or third order, are clearly stated, and their *most direct and simple* applications thoroughly understood. It should, most emphatically, not be thorough in the sense that a relatively small number of topics are exhaustively studied, or that any particular topic is turned over and looked at from every possible point of view. All these are obviously the functions of advanced courses.

All of us realize, to be sure, that the ripe fruits of physics training cannot be secured in the brief span of the high school course. We realize, too, that all we can expect to do is to start the student in the right way; to inspire him to want to study the subject more; to show him enough of what it is like, and what it enables him to do, to lead him to come back later on to his elementary text-book and review first principles in their relation to new knowledge which comes to him, or to new difficulties which confront him. We realize, in short, that the purpose of a first course is to *open up the field*, and we should be very careful, I think, not to commit what has been perhaps the greatest mistake of the past two decades, namely, that of attempting to carry our pupils so far into the details, subtleties and refinements of the subject in the high school course, that they *lose sight of the woods on account of the trees*. The course must not be so intensive as to destroy perspective, nor so restricted as to fail to leave upon the student's mind a vivid picture of what is the extent of the field covered by the subject, what is the method which it uses, and what are the *foundation* principles which underlie it.

XII. By Lewis B. Avery.

Principal of the High School, San Jose, Cal.

In advising any change in the matter or manner of teaching physics in high schools, or for that matter in advising any educational changes, I am fully aware that the burden of proof rests with those who give the advice. There is no doubt that education must be conservative rather than erratic or sporadic in its

mode of progress. But when it is considered that the past few years have seen a greater progressive change in community life, ideals, and knowledge than the world has before known in the same time, it is not to be wondered at that the educational barometer presages unusual disturbances. The period when accomplishments were sought and that when scholarship was made the chief goal, have given place to the era of the specialist in both professional and technical lines. While other aims and purposes may influence the many, yet the flower of today's education is the specialist and this fact has determined both curriculum and method. I do not think that we are on the eve of doing away with our experts, discounting scholarship, or showing ourselves unappreciative of real accomplishments, but in the future, as in the past, we will get along with comparatively few experts, scholars, and accomplished people. The old academy expected to educate only the "fit," that term being very exclusive in its application. The public high school has exceeded the fondest hopes of its projectors. From about two hundred high schools thirty years ago, we have about seven thousand today, and in those communities where the high school is most popular it finds itself endeavoring to educate a large proportion of the young people of the community—indeed, is engaged in transmuting the "unfit" into the "fit." Far from being a school for the select, the high school today is becoming peculiarly a school for the masses. Yet its curriculum, and to a large extent its methods, remain those of the preparatory school—a school preparing people to become specialists.

History is today arranged and taught largely according to the recommendation of The Committee of Seven. I was privileged a few days since to listen to a discussion of the report of The Committee of Seven by the Pacific Coast Branch of the American History Association. I was not altogether surprised to hear a member of that illustrious Committee and a prominent professor of a large university both agree that history had no place in the secondary schools—even characterizing ancient history in the early years of high school as "cruelty to animals." A similar opinion is held by prominent university scientists regarding the various sciences in secondary schools. While these views are extreme and would not, I am sure, meet approval with secondary school people, who recognize that it is not the subject nor yet the method, but the teacher that is the prime consideration in

secondary education, still I think that the feeling is distinctly growing that the methods of specialists are not well fitted for the education of the masses. It is further evident that while the universities have without question assisted in perfecting the present high school system to an extent that would have been altogether impossible without them, yet, with notable exceptions, they do not and perhaps can not take the high school point of view—that of the education of the masses rather than the preparation of experts.

This is peculiarly a scientific era. Its record of victories over natural forces and its discovery of hidden treasures has put into our hands an Aladdin's lamp. The public, unlettered in science, are fairly superstitious in their devotion to it, and the public press more than reflects this condition of the public mind. But how have our high schools, the people's colleges met this advance of science? I can not forbear calling attention to the interest that prevailed in the physics classes of earlier years when many a physics master of today received his inspiration in what seemed a fairy land of science. The equipment then was meager, the teacher's understanding of the subject scant, the text books comparatively inadequate, not to say inaccurate. Today the scientific laboratories of our high schools would put to shame the college laboratories of those days, our text books superbly second the equipment of the laboratories, and the teachers are specialists in the subjects. Combining these facts with the general interest in science, with its wide application in daily life, and with the large amount of popular scientific literature in newspapers, magazines, and books, we might readily expect the interest in that department of high school work to be at its zenith. I need hardly call for testimony. We all know that the science department today remains the department for the select and not the masses. The following figures taken from the most recent report of the United States Commissioner of Education are fully in accord with what I have said. During eleven years past the percentage of high school pupils studying astronomy has dwindled from 4.4% to .91%; geology from 4.8% to 2.31%; physiology from 31.9% to 20.36%; chemistry from 8.95% to 6.52%; physics from 22.08% to 15.27%.

The only possible justification for this condition of things is that the secondary school is preparing its pupils for the university in a better way than formerly. I should be perfectly willing to concede this and still believe the argument as wholly without

force in the face of the need of the entire community for ordinary scientific education and the enormous expense of maintaining the science departments in the high schools as compared with other departments. But I have had it direct from university teachers of entering students that they practically have to repeat the secondary work in physics anyhow, and hold it but little in respect. I doubt if this opinion is general among teachers of entering students, but, if it is, the argument against present methods is certainly overwhelming and complete. But no such arguments are necessary or desired to make it seem advisable that the sciences, and particularly physics, be given a more popular presentation.

Physics teaching has been conducted with the engineer rather than the boy and girl to be taught in view. The logical method of the subject has been followed. It has been "from the simple to the complex." From the primary school up, with the sole exception of the sciences, that method of attack has been abandoned. The child of today finds "butterfly" just as easy to read as his father did his "a-b-ab" and very much more vital. Even Latin has ceased to require the committing to memory of the entire grammar before reading begins. "From the lever to the steam engine" is the movement of one who is consciously becoming an engineer, but the preparation for that movement should be a study that shall lead from the engine to the lever. The lever can have life and meaning only in the light of the engine. The very fact that boys largely surpass girls in the study of physics is because they have the engine—the whole field of physics—more in mind than have the girls. The elements of physics are to them thus fraught with something of meaning that is lacking in the case of those to whom a lever is a stick and nothing more. If the course in physics can be made vital, it is my opinion it should be made so whether it remains technical or not. The necessities of the community should stand supreme. I am, however, fully convinced that the right presentation of the phenomena of the field of physics will aid rather than hinder in the preparation of pupils for technical courses to be taken thereafter. Who would think of setting the grade stakes for a railroad without a preliminary survey of the route! Pupils who know whither they are tending and feel some interest in results to be obtained and who are in sympathy with the field they are investigating, will accomplish more and better work in the laboratory than those who go

through the treadmill of laboratory exercises unillumined by interest or intelligence regarding the matter in hand. I know that there is a feeling that pupils should not be prejudiced in their experimental work and that there should be no glow of expectation to mar the accuracy of their results—God save the mark!—but as I have had occasion before to observe "The magnificence of the repressed, controlled and directed power of the great scientist is only stimulated by the high school student, but in the latter case it is generally nonchalance and patronizing disinterestedness. Self-control and death may have some points in common but their difference is life."

But as for the average pupil who is going into life with no further school education, or who is not to get more physics in college, such knowledge of the field as can be given in a year, or even in a half year, by a strong teacher with modern equipment, will leave him at least with a vital interest in natural phenomena and their explanation—a result far from being obtained today even with the picked few of the fourth year pupils in our high schools.

In suggesting such a course I am not entirely without the test of experience. For several years I have prefaced the conventional course in physics with a half year into which have been crowded the most interesting physical phenomena possible. Beginning with light as one of the most interesting portions of the field, we have daily given the best possible exhibition of its phenomena capable of popular explanation, and have made the class hour one of question and answer regarding the experiments of the day, the questions coming largely from the class. No text book has been used, but the written account of each day has served as a card of admission for the day following. The work has apparently been a source of inspiration to pupils and teacher and those who have taken it have shown a general knowledge of the subject obtained in a half year fairly comparable with that obtained in a year by ordinary methods and have exhibited vastly more interest in it. The conventional course in physics given the year following has been wholly elective and those taking it have accomplished much more in laboratory and text than has ordinarily been done.

As before contended, it seems but reasonable that an acquaintance with the field of phenomena would give a life and zest to later individual experiments that would otherwise seem tedious

and unattractive and it will also give some scientific light to that portion of the community now left wholly in the dark in so far as ordinary scientific concepts are concerned.

In conclusion, I advise a strongly presented popular course in physics to be given not later than the third year of the high school course and to be generally required. It should aim to secure in girls as well as boys a vital interest in physical phenomena and their rational interpretation. Such a course may be followed by a purely elective year or more of laboratory physics.

I am further of the opinion that the time approaches when our colleges, instead of insisting that the education that fits for college necessarily fits for community life, will agree that the education that fits for community life necessarily fits for college.

PROGRESS.

Those who can recall the laboratories of twenty and twenty-five years ago will remember how rare was the microscope, especially for the use of individual students. Not only microscopes, but other scientific instruments, such as microtomes, projection apparatus, etc., were unknown in the majority of small schools. The progress has been gradual and we have become accustomed to modern equipment without realizing the extent which the development has reached.

We are forcibly reminded of this progress by the information given in a recent publication—"A Few Facts and Figures"—issued by the Bausch & Lomb Optical Co., of Rochester, N. Y. The development of this scientific establishment since its foundation is an index to the growing demands which science makes upon the producers of reliable apparatus. In 1853 the company had no employees and occupied but a few feet of space. Today ten acres of floor space is utilized by 1,800 employees.

This one concern has supplied over 66,000 compound microscopes besides a great many dissecting stands, quantities of hand magnifiers, over a million high grade photographic lenses, etc. One interesting item is 20,000 oil immersion objectives for the microscope. These were introduced only a few years ago; 5,500 precise microtomes have been made besides numerous photo-micrographic and projection equipments. Other departments have been added from time to time, including precision glassware, made in their own factory in Germany, the original Ganong Apparatus for the study of plant physiology, etc. Twenty million eyeglass lenses are produced annually.

But this is not the most important feature. Of greater importance has been the reduction of the cost of equipment to schools while at the same time the quality and efficiency of the various instruments have been wonderfully bettered. This has been accomplished through the employment of highly modernized technical equipment and the research work of a competent and experienced scientific staff. The alliance with the Carl Zeiss Optical works of Jena, announced a year ago in the booklet called "A Triple Alliance in Optics", assures even better things for the future.

PROBLEM DEPARTMENT.

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Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.

Algebra.

128. *Proposed by J. J. Browne, Golden, Colo.*

Solve

$$bx + cy + az = bc + ca + ab$$
$$cx + ay + bz = bc + ca + ab$$
$$x^2 + y^2 + z^2 = a^2 + b^2 + c^2$$

Solution by E. B. Escott, A.M., Ann Arbor, Michigan.

We see by inspection that one solution is $x=a$, $y=b$, $z=c$.

Let $x = a + u$, $y = b + v$, $z = c + w$

The equations become

$$bu + cv + aw = 0 \quad \ldots\ldots(1)$$
$$cu + av + bw = 0 \quad \ldots\ldots(2)$$
$$u^2 + 2au + v^2 + 2bv + w^2 + 2cw = 0 \quad \ldots\ldots(3)$$

Eliminating u between (1) and (2) we have

$$\frac{v}{w} = \frac{b^2 - ac}{c^2 - ab} \quad \ldots\ldots(4)$$

Put $v = (b^2 - ac)s$ ..... (5)

Then $w = (c^2 - ab)s$ ..... (6)

$u = (a^2 - bc)s$ ..... (7)

Substituting these values in (3) we find $s = 0$ and

$$S = -\frac{2(a^3 + b^3 + c^3 - 3abc)}{a^4 + b^4 + c^4 - 2a^2bc - 2b^2ac - 2c^2ab + b^2c^2 + c^2a^2 + a^2b^2}$$

or, by taking out common factor

$$a^2 + b^2 + c^2 - ab - bc - ca$$

from numerator and denominator

$$S = -\frac{2(a + b + c)}{a^2 + b^2 + c^2 + ab + bc + ca}$$

which gives for solutions of the original equations

$$x = a, \quad y = b, \quad z = c;$$

$$x = a - \frac{2(a + b + c)(a^2 - bc)}{a^2 + b^2 + c^2 + ab + bc + ca},$$

$$y = b - \frac{2(a + b + c)(b^2 - ac)}{a^2 + b^2 + c^2 + ab + bc + ca},$$

$$z = c - \frac{2(a + b + c)(c^2 - ab)}{a^2 + b^2 + c^2 + ab + bc + ca}.$$

129. *Proposed by Gertrude L. Roper, Detroit, Mich.*

Explain the following fallacy:

$$16 - 36 = -20 = 25 - 45,$$
$$\therefore 16 - 36 + {}^{81}/_{4} = 25 - 45 + {}^{81}/_{4}$$
and therefore $(4 - {}^{9}/_{2})^2 = (5 - {}^{9}/_{2})^2$,
and since $4 - {}^{9}/_{2} = 5 - {}^{9}/_{2}$, $4 = 5$.

Solution by Wm. B. Borgers, Grand Rapids, Mich.

In the third step, one of the square roots of the left member equals one of the square roots of the right member, but not the principal (positive) root. The fallacy consists in assuming that the principal square root of one equals the principal square root of the other.

130. A and B traveling the same road were at two towns a miles apart at the same time. On coming together it was found that A, the faster traveler, had gone b miles and that the time was equal to the difference of their rates. Find their rates.

I. Solution by A. M. Allison, Moline, Ill., and M. H. Pearson, Dothan, Ala.

Let x = A's rate, and y = B's rate; then $x - y$ = no. hrs. each travels.

$\frac{b}{x}$ = no. hrs. A travels. $\frac{a-b}{y}$ = no. hrs. B travels,

(1).... $\frac{b}{x} = \frac{a-b}{y}$. $\therefore y = \frac{a-b}{b}x$,

(2).... $\frac{b}{x} = x - y$ or $b = x^2 - xy$.

Substituting value of y from (1) in (2) and solving, $x = \frac{b}{2b-a}\sqrt{2b-a}$.

Substituting value of x in second part of (1), $y = \frac{a-b}{2b-a}\sqrt{2b-a}$.

II. Solution by P. S. Berg, Dickinson, N. Dakota.

Let x = the time it takes A to travel b miles, and B to travel $a - b$ miles.

Then, $\frac{b}{x}$ = A's rate, and $\frac{a-b}{x}$ = B's rate. $\frac{b}{x} - \frac{a-b}{x} = x$. Whence,

$\frac{b}{x} = \frac{b}{\pm\sqrt{2b-a}}$, A's rate, and $\frac{a-b}{x} = \frac{a-b}{\pm\sqrt{2b-a}}$, B's rate.

III. Solution by D. W. Duguid.

Let x = the time, y = A's rate; then $y - x$ = B's rate. We have $xy = b$, $xy - x^2 = a - b$, and from these equations

$$x = \sqrt{2b-a}, \quad y = \frac{b}{\sqrt{2b-a}}, \quad y - x = \frac{a-b}{\sqrt{2b-a}}.$$

Geometry.

131. *Proposed by Jno. A. Hodge, New Albany, Ind.*

Two ladders, 80 and 100 ft. long, have their bases on the opposite sides of a street and lean on the walls of buildings opposite them. If from their point of intersection to the ground it is 10 ft., what is the width of the street?

Solution by G. B. M. Zerr, Ph.D., Philadelphia, Pa.

Let AC $= a = 100$ feet, BD $= b = 80$ feet, E the intersection of AC, BD, EF $= c = 10$ feet. Also let BC $= x + y$, AD $= x - y$, AF $= z$, BF $= w$. Then $w : c = w + z : x - y$ or $c(w+z) = w(x-y)$.

$z : c = w + z : x + y$ or $c(w + z) = z(x+y)$.

$$\therefore w = \frac{z(x + y)}{x - y}.$$

This value of w in $c(w + z) = z(x + y)$ gives $2cx = x^2 - y^2$

$$\therefore x = c + \sqrt{c^2 + y^2} \quad \ldots\ldots\ldots\

Applied Mathematics.

133. *Proposed by Irvin E. Kline, Blairstown, N. J.*

A rifle ball is let fall from a balloon 500 ft. high, on a lake 40 ft. deep. How long until it reaches the bottom of the lake?

Solution by E. L. Brown, M.A., Denver, Colo.

Let K_1 = coefficient of resistance of air, K_2 that of water; t and T = times of falling through distances s_1 and s_2; $K_1\left(\frac{ds_1}{dt}\right)^2$ = the resistance of the air at any point, and acts upwards; g = the accelerating force downwards; hence the resultant acceleration is

$$\frac{d^2s_1}{dt^2} = g - K_1\left(\frac{ds_1}{dt}\right)^2 \quad \ldots\ldots (1)$$

$$\text{or } \frac{d\left(\frac{ds_1}{dt}\right)}{K_1 dt} = \frac{g}{K_1} - \left(\frac{ds_1}{dt}\right)^2$$

$$\therefore K_1 dt = \frac{d\left(\frac{ds_1}{dt}\right)}{\frac{g}{K_1} - \left(\frac{ds_1}{dt}\right)^2}$$

$$\therefore K_1 t = \frac{1}{2}\left(\frac{K_1}{g}\right)^{\frac{1}{2}} \log \frac{g^{\frac{1}{2}} + K^{\frac{1}{2}}\frac{ds_1}{dt}}{g^{\frac{1}{2}} - K^{\frac{1}{2}}\frac{ds_1}{dt}} + C_1 \quad \ldots\ldots (2)$$

$C_1 = 0$, since $\frac{ds_1}{dt} = 0$ for t and $s = 0$

Eq. (2) gives t in terms of $\frac{ds_1}{dt}$ or v, and constants

Multiplying Eq. (1) by ds_1 we can put it in the form

$$2K_1 ds_1 = \frac{d\left(\frac{ds_1}{dt}\right)^2}{\frac{g}{K_1} - \left(\frac{ds_1}{dt}\right)^2}.$$

$$\therefore 2K_1 s_1 = -\log \frac{g - K_1\left(\frac{ds_1}{dt}\right)^2}{g} + C_2;$$

$C_2 = o_1$ since $\frac{ds_1}{dt} = o$ for $s_1 = o$.

$$\therefore \frac{ds_1}{dt} = v = \sqrt{\frac{g}{K_1} - E^{-2K_1 s_1}} \quad \ldots\ldots (3)$$

Eq. (3) gives v in terms of s_1 and constants; then will Eq. (2) give t. Hence t is known as soon as K_1 is given.

Let V_0 = velocity of ball when it reaches surface of lake.

Just as before we find

$$K_2 T = \frac{1}{2}\left(\frac{K_2}{g}\right)^{\frac{1}{2}} \log \frac{g^{\frac{1}{2}} + K_2^{\frac{1}{2}}\frac{ds_2}{dT}}{g^{\frac{1}{2}} - K_2^{\frac{1}{2}}\frac{ds_2}{dT}} + C_3$$

Since $\frac{ds_2}{dT} = V_0$ when $T = 0$, we have

$$C_3 = -\frac{1}{2}\left(\frac{K_2}{g}\right)^{\frac{1}{2}} \log \frac{g^{\frac{1}{2}} + K_2^{\frac{1}{2}} V_0}{g^{\frac{1}{2}} - K_2^{\frac{1}{2}} V_0}.$$

$$\therefore K_2 T = \frac{1}{2}\left(\frac{K_2}{g}\right)^{\frac{1}{2}} \log \frac{\left(g^{\frac{1}{2}} + K_2^{\frac{1}{2}} \frac{ds_2}{dT}\right)\left(g^{\frac{1}{2}} - K_2^{\frac{1}{2}} V_0\right)}{\left(g^{\frac{1}{2}} + K_2^{\frac{1}{2}} \frac{ds_2}{dT}\right)\left(g^{\frac{1}{2}} + K_2^{\frac{1}{2}} V_0\right)} \quad \ldots\ldots(4)$$

Also, we find

$$2K_2 s_2 = -\log \frac{g - K_2\left(\frac{ds_2}{dT}\right)^2}{g} + C_4$$

When $s_2 = 0$ $\frac{ds_2}{dT} = V_0$,

$$\therefore C_4 = \log \frac{g - K_2 V_0^2}{g}$$

$$\therefore 2K_2 s_2 = \log \frac{g - K_2 V_0^2}{g - K_2\left(\frac{ds_2}{dT}\right)^2}$$

$$\therefore E^{2K_2 s_2} = \frac{g - K_2 V_0^2}{g - K_2\left(\frac{ds_2}{dT}\right)^2}$$

$$\therefore \frac{ds_2}{dT} = \left[\frac{g - (g - K_2 V_0^2)\, E^{-2K_2 s_2}}{K_2}\right]^{\frac{1}{2}} \quad \ldots\ldots(5)$$

From Eqs. (4) and (5) we find T, which with t gives us the entire time required to reach bottom of lake. Hence the problem is solved when K_1 and K_2 are given.

II. Solution by I. L. Winckler, Middlebury, Vt.

The time to reach the surface of the lake is obtained from $s = \frac{1}{2}gt^2$. This gives $t = 5.57+$ seconds.

The velocity when bullet reaches surface of lake, neglecting resistance of air is $v = gt = 32.2 \times 5.57 = 179.35$ ft. per second.

If the resistance of the water is neglected we could get the time from the surface of the lake to bottom by equation $s = \frac{1}{2}g't^2 + v_0 t$ where $g' = g(1 - a) = \frac{103}{113}g$ (a = ratio of density of water to that of lead)

and $V_0 = 179.35$ ft.

$s = 40$

$\therefore t = .22$ sec. nearly

$\therefore$ Total time $= 5.79$ sec.

If the resistance of the water is supposed to vary as the nth power of the velocity we should have for determining the time from surface to the bottom the differential equation

$$\frac{d^2x}{dt^2} = g(1 - a)\left[1 - k\left(\frac{dx}{dt}\right)^n\right],$$

$$\text{or } g(1 - a)dt = \frac{d\left(\frac{dx}{dt}\right)}{1 - k\left(\frac{dx}{dt}\right)^n}.$$

Note. When $n = 2$ this becomes $g(1 - a)dt = \dfrac{d\left(\dfrac{dx}{dt}\right)}{1 - k\left(\dfrac{dx}{dt}\right)^2}$, from which x can readily be found as a function of t.—*Ed.*

CREDIT FOR SOLUTIONS RECEIVED.

Geometry 120. M. H. Pearson (1).

Algebra 123. D. W. Duguid (1).

Algebra 124. D. W. Duguid, Christopher Maher, Orville Price, R. R. Snapp (4).

Algebra 125. D. W. Duguid, Orville Price, Eugene R. Smith (3).

Geometry 126. Gertrude E. Allen, T. M. Blakeslee, Orville Price, G. W. Towne (4).

Trigonometry 127. D. W. Duguid, Orville Price (2).

Algebra 128. P. S. Berg, E. L. Brown, J. J. Browne, E. B. Escott, G. W. Towne, I. L. Winckler, G. B. M. Zerr (7).

Algebra 129. C. Belzerg, P. S. Berg, T. M. Blakeslee, Wm. B. Borgers, E. L. Brown, Joseph W. Clokey, D. W. Duguid, D. L. Hines, Jno. A. Hodge, Raymond R. Ritchie, R. R. Snapp, Minnie R. Snow, F. J. Taylor, G. B. M. Zerr (14).

Algebra 130. A. M. Allison P. S. Berg, T. M. Blakeslee, Wm. B. Borgers, D. W. Duguid, D. L. Hines, Jno. A. Hodge, M. H. Pearson, Edwin Reese, R. R. Snapp, Raymond R. Ritchie, Minnie R. Snow, I. L. Winckler, G. B. M. Zerr (14).

Geometry 131. Wm. B. Borgers, E. L. Brown, G. W. Towne, I. L. Winckler, G. B. M. Zerr (5).

Geometry 132. A. M. Allison, P. S. Berg, T. M. Blakeslee (two solutions), E. L. Brown (two solutions), D. E. Congdon, D. L. Hines, W. F. Jones, M. H. Pearson, Raymond R. Ritchie, G. W. Towne, J. F. West, I. L. Winckler, G. B. M. Zerr (15).

Applied Mathematics 133. E. L. Brown, I. L. Winckler, G. B. M. Zerr (3).

Total number of solutions, 73.

PROBLEMS FOR SOLUTION.

Algebra.

139. Find whether the following series is convergent or divergent.

$$\frac{1}{x} - \frac{1}{x+a} + \frac{1}{x+2a} - \frac{1}{x+3a} + \cdots\cdots.$$

x and a being positive.

140. *Proposed by W. T. Brewer, Quincy, Ill.*

Solve $x^2y + y^2x = a$

$x^2 - y^2 = b$

Geometry.

141. *Proposed by A. Latham Baker, Ph.D., Brooklyn, N. Y.*

Given P. Q. R. the three angles of a triangle, with the mid point of one side at a fixed mid point between two parallels, and the two vertices on the parallels. What is the locus of the third vertex?

142. *Proposed by D. W. Duguid, Dansville, Mich.*

To construct the expression $x = \frac{2abc}{de}$; that is $\frac{2ab}{d} \times \frac{c}{e}$. (Wentworth's Geometry, revised edition).

Applied Mathematics.

143. *Proposed by O. R. Sheldon, Chicago, Ill.*

A ball is placed upon a given horizontal plane. Determine its position in the time t.

INTRODUCING THE METER AND KILO IN DENMARK.

The introduction of the Metric System in Germany in 1870 is so often referred to as a rather ideal method, that it may be well to trace the steps by which Denmark, the last State to go over to the majority, is achieving its end, as an example to her three unconverted sisters.

Time intervals are always an important factor in a revolution of this sort, perhaps the most important. In this respect Denmark has made an ideal example. An interval of nearly three years is given after the passage of the law before the Government is required to use it in any of its branches, unless by earlier decree of the king. Then a further space of two years intervenes ere its use is required of the people at large. This period of 4 to 5 years gives ample time to prepare for the change, in having the subject better taught in schools, in tradesmen accustoming themselves to different quantities and the people to new names.

For years the land of the Jutes has been one of the four laggard nations in metric reform matters, though time and again the question has been before its Congress. In 1899 a compulsory metric bill passed the Upper House, only to be turned down in the Lower, because the ignorant rural constituents of the members were opposed to any change. The English Consul at the time wrote: "It appears that the great bulk of the commercial and professional people of this country, as well as the shopkeepers, are in favor of the Bill, but that the Representatives of the peasants in the Second Chamber, who form the majority in that House, believe that it would be unpopular with their electors."

Probably no state ever introduced a similar measure that did not meet a like objection. At length brains and judgment overcame ignorance, inertia, and ancestor worship, and on March 9, 1907, a compulsory metric bill passed the Second Chamber and became law. So

complete and exact is this law that changes or additions seem unlikely for many years. It should be noted that ever since 1861 the Danes have been using metric weights of 500 grams under the old name *pound*, so only the name will indicate the change. Government reports also on railroads, etc., have been made in metric figures.

The most important parts of the Law are as follows:

"The basis of the Danish system of measures is the metre. The basis of the Danish system of weights is the kilogram. Other units of measure and weight are derived from the two above named, according to the decimal system."

"It may be determined by Royal Order what abbreviations are to be used" for metric tables given.

"From a period to be further fixed by the King, but not later than three years after the issue of the present law, metric measures and weights shall be exclusively used in the calculation of duties and other public charges. From that time appliances for measurement and weights in accordance with the present system shall no longer be tested, unless they are for use in Iceland or the Danish West Indian Islands, but the readjustment of *such* appliances may take place."

"For the same period the use of metric appliances for measurement and weight shall be permitted in trade and commerce, when the parties agree thereon."

"Two years from the above-mentioned period metric measures and weights shall be exclusively used with the exceptions mentioned."

"For measurements in connection with the register of land, the area may also be given in square ells until the year 1925."

Many other items are given in the law; for example punishments for violation of the law, the salary and duties of the director, tables, etc. Thus by the year 1912 the Danes will use the metric system, and the transition will be as easy as it has been found to be in all civilized countries where the International System has replaced an older.

R. P. W.

THE MESSINA EARTHQUAKE.

The following editorial on the Messina earthquake taken from the *Independent* of January 7 is worth while reading even for the men of science well acquainted with the subject. It is seldom that a newspaper, even a weekly newspaper, presents its readers with ideas so clear and so correct on a subject which few but specialists are competent to write upon. The readers of SCHOOL SCIENCE AND MATHEMATICS know too well how erroneous and grotesque are the ideas which young people get from newspaper science. It is astonishing that intelligent parents permit their children to read, and believe, the monstrous things that are published, especially in the Sunday newspaper, as new discoveries in science. The editorial quoted is proof that there are men competent to write on scientific subjects in a popular way. It is strange that the great newspapers do not employ competent scientists to edit the news involving questions on which they are fitted to pass judgment.—ED.

There are two great earthquake belts in the world, one encircling the Pacific Ocean, the other extending nearly east and west and including Central America, the West Indies, the Mediterranean, Asia Minor, and Southern Asia. In the second belt one of the regions most liable to severe shaking is the Mediterranean, and every few years a strong and destructive earthquake occurs there, while in the intervals between there are hundreds of minor shocks. This is because the Mediterranean basin is a great sunken block of the earth's crust in which the downward movement is still in progress. As the sinking continues adjustments of the rock layers are made necessary, and when the strain becomes sufficiently powerful relief is obtained by the sliding of the strata along a plane of breakage called a fault plane. Then an earthquake is generated by the jarring and grinding of the rocks together as they slip, and the intensity of the shock varies with the amount of movement. Sometimes it is only enough to cause a tremor, passing unnoticed except where recorded by delicate instruments; or it may be a movement of sufficient strength to be felt by seismographs in all parts of the world, and to cause vast destruction near the center of disturbance.

In the Mediterranean region no section is subject to more frequent and destructive earthshaking than that of the southern end of Italy, called Calabria, and the neighboring island of Sicily; for here there are many fault lines along which relief is found from the strains that are set up in the crust. Among these fault lines, long known to students of earth history, is the one that extends along the Strait of Messina. Indeed, the Strait of Messina has been caused by movements along this line of faulting, and the separation of Sicily from the mainland is of recent date, speaking in terms of geological history. The recent earthquake which has so horrified the world is evidently due to a renewal of movement along the fault line of the Strait of Messina. It is not the first earthquake generated by movement along this fault line, and in all probability it is not the last one.

The proximity of Mount Etna has naturally given rise to a widespread belief that the Messina earthquake is in some way related to volcanic action connected with Etna itself. The relation of earthquakes to volcanoes is a subject too abstruse for discussion here, but it may be said that volcanic action and earthquakes are not necessarily related, for we have had many very severe shocks, like that of San Francisco, far removed from the nearest active volcano. Even in the Messina earthquake it is to be noted that the most severe shaking was not near Etna, nor near the volcano Stromboli to the north, but about midway between the two. The shock was, without doubt, generated beneath the waters of the strait by movements of the underlying rocks, although it cannot be denied that the movement itself may in some way be related to the presence of lava in this region of notable volcanic activity. Science has not yet found it possible to give definite interpretation to those hidden phenomena within the earth, as a result of which volcanoes burst into eruption and great masses of rock slide over one another in the process of mountain formation and the settling of basins.

Measured in terms of destruction of life and property, the newspaper reports indicate that the Messina earthquake is to rank among the great horrors of the world's history. Hitherto the Lisbon earthquake of 1755, when 60,000 people were killed, has been in the first rank among the cataclysms of Nature, though some of the earthquakes of Southern Asia have destroyed far more lives. It may surprise people to know that, notwithstanding the vast destruction of life caused by this most recent of great earthquakes, it does not rank among the strongest shocks even of the present year. The seismographic records show far less disturbance than many a shock about which the public has heard nothing. It is the unfortunate location of the fault line, in a densely settled region, and beneath the sea, close by two cities, that has given rise to such frightful disaster.

Four phenomena associated with earthquakes are responsible for most of the loss of life—the falling of buildings, the starting of a conflagration, the development of a tidal wave, and the opening of fissures in the earth, as at Lisbon, in which people may be swallowed up and entombed. Any one of these may cause great loss of life, and usually not more than one, or at most two of these, are combined; but when there are three of these phenomena resulting from the earthquake, the destruction may become appalling. It was the occurrence of the three first of these in combination that gave to the Messina earthquake its terrible power of destruction. Heavy stone buildings, thrown down in cities located close by and on either side of the fault plane on which the earthquake was generated, caused great loss of life, which was further increased by the fires that naturally followed. Then came a water wave, generated by the movements of the strata beneath the strait. Had the fault line been on land, as was the case in the San Francisco earthquake, or had the shock been generated by eruptions of Etna, the horror of the so-called tidal wave would not have been added to that of falling buildings and fire.

We are gaining much knowledge about earthquakes, and some day, it may be hoped, this knowledge will be applied to the preservation and protection of life and property. One lesson that has been learned again and again is that the location of a city on or close by a fault line where movements are still in progress is a dangerous one. All things considered, it would be safer, and perhaps wiser, to abandon such a site as that occupied by Messina or Reggio; or, failing that, it is a matter of public duty, which the Italian Government has already recognized, to see to it that buildings erected on such a site are so constructed as to resist earth-shaking, and placed in a position safe from the frightful destructiveness of the tidal wave.—*The Independent.*

DEPARTMENT OF SCIENCE QUESTIONS.

By Franklin T. Jones,

University School, Cleveland, Ohio.

Please send lists of the laboratory exercises in Physics that you will use this year. Numerous and representative answers are desired.

The one point upon which the Committee of Ten was unanimous was that the teaching of Physics and other sciences should be the same for the boy who is going to college and the boy who is not, or, in other words, the best preparation for life is also the best preparation for college. Recent agitation and discussion would lead one to believe—

(1) That the requirements of the colleges for admission were not in accord with this statement;

(2) That the teachers also were losing sight of the things best for the student in their attempt to prepare the few for admission to college;

(3) That modern and progressive teachers in the sciences were "rattling dry bones" and depriving the growing boy of those matters that interest him instead of giving full swing to the possibilities of their well-equipped laboratories;

(4) That teachers in the small schools were not doing very good work because they were trying to ape the ways of the colleges.

Are not such assertions more or less preposterous on the face of them? Are we, as teachers, ready to confess that we can not do pretty much as we please in shaping the details of our courses, and that, with such freedom, we are therefore (if we accept the judgment of some of our highest educational authorities) really making failures of our chosen work? Is not our practice and our theory better than it was even ten years ago, and are we not on the up path rather than the down? It seems to the editor of this department that it is about time for us science teachers to champion strongly what we *are* doing, or else as we have almost perfect freedom to do, on our own individual initiative, change to the best thing.

The most vital "Science Question" at the present time is involved in the above statement.

As a sample of the college point of view as reflected in examinations for entrance, part of the September, 1908, papers from Columbia University follow. In what respects would a teacher do differently in preparing students for these examinations than if he were giving them what he considered best in preparing them for life?

Entrance Examination in Botany

September, 1908.

Note.—Time: Two hours, ten minutes of which will be devoted to an oral examination. The certified notebook on the laboratory work must be submitted at the examination.

1. What structures of the leaf are of advantage in photo-synthesis? Explain in what way each one is of service.

2. What is the cause and mechanism of the curvature of tendrils?

3. How is the root protected against injury? How does it absorb materials from the soil? What other functions does it perform?

4. Make a sketch of the important stages in the life of a fern, labeling the various parts.

5. In what respects does the seed of a Monocotyledon usually differ from that of a Dicotyledon?

6. Mention the agencies that promote the distribution of plants, with illustrations of the adaptive features. What factors control the association of plants upon the earth?

7. Give the characteristics of six families of seed plants that you have studied.

Entrance Examinations in Chemistry.

September, 1908

Note.—Time: Two hours. Candidates are required to present their certified notebooks on forty experiments as a part of the examination.

A

Answer all questions in this group.

1. A certain volume of gas measures 100 c.c. at 10° C. and 750 mm. pressure. What will it measure at 0° C. and 760 mm. pressure? (See data below.)

What is the weight of 10 liters of sulphur dioxide measured at 0° C. and 760 mm. pressure?

What weight of potassium chlorate must be heated to obtain 100 grams of oxygen?

Data: Atomic weights: S=32, O=16, K=39, Cl—35.5. Use .09 gram as the weight of one liter of hydrogen at 0° C. and 760 mm. pressure.

2. Define and illustrate base, reversible reaction, electrolyte, nascent state, dibasic acid.

Sixteen grams of oxygen combine with two grams of hydrogen, and three grams of magnesium combine with two grams of oxygen. Calculate the equivalent for magnesium.

3. Complete the following equations using formulas:

Potassium nitrate and sulphuric acid (heated)=?

Carbon monoxide and copper oxide (heated)=?

Ferrous sulphide and dilute sulphuric acid=?

Calcium carbonate and dilute hydrochloric acid=?

B

Answer two questions from this group.

4. Describe, in full, the experiments you performed illustrating the methods of preparation and the physical and chemical properties of ammonia. Give the equations for all the chemical reactions.

5. Describe experiments showing that

(*a*) calcium oxide is a basic anhydride,

(*b*) water is an aid to some chemical reactions,

(*c*) the air contains oxygen, carbon dioxide, and water vapor.

Describe an experiment illustrating the law of definite proportions.

6. Describe laboratory methods for the preparation of chlorine, silver nitrate, hydrofluoric acid, nitrous oxide. Give equations.

C

Answer two questions from this group.

7. What are the physical or chemical properties of each of the following that make them directly useful to mankind? Oxygen, Chlorine, Carbon (coal), Tin, Copper, Iron, Zinc.

8. What is the nature of the most important chemical change which occurs during the production of pig iron from its ores in the blast furnace? How does a steel differ chemically from a pig iron? Give the names of two processes for the production of steel from cast iron. Define the terms "ore" and "flux."

9. Give three methods for the preparation of salts using sodium chloride as an example.

In what respects do chlorine, bromine, and iodine resemble each other, and in what respects do they differ from each other?

Entrance Examination in Physiography.

September, 1908.

Note.—Time: Two hours. Candidates are required to present their certified notebooks on the forty exercises as a part of the examination, and also to answer the following questions as concisely as is consistent with clearness and definiteness. Use diagrams as freely as desired.

1. Mention as many ways as you can by which the true north may be determined. How would a true north and south line vary from the compass direction at New York and at San Francisco?

2. Explain the following terms: equinox; block mountain; young valley; escarpment; high.

3. Compare the distribution of rainfall along the western coast of the United States with that along the eastern coast. Account for the variation between the summer and winter rainfall of the northern Mississippi Valley.

4. Show by a diagram the atmospheric conditions about a cyclone, including temperature, pressure and rainfall.

5. Describe the shore features to be seen along a regular shore line. Account for the location of Portland, Me.; Norfolk, Va.; and Boston, Mass.

6. Compare the surface features in a glaciated with those in a non-glaciated region. Describe the occupations to be seen in a glaciated region like Maine and show how these occupations are related to the glacial features.

7. Mention four regions in this country where lakes abound and explain the origin of the lakes in each region.

8. What phenomena of the ocean are due to the earth's rotation? Explain the relation.

ARTICLES IN CURRENT MAGAZINES.

Camera Craft for January: "Making Enlarged Negatives," H. D'Arcy Power; "Bromide Enlarging Matters," Preston E. Anderson; "Shutter Mechanism," Gustav Dietz; "The Camera at Night," E. Stanley Thomas; "Some Simple Lens Tests," S. Stockton Horner.

Mining Science for November 26: "The Great Iron Fields of the Lake Superior District," Robert B. Brinsmade; "The Retort Coke Oven as Used in Destructive Distillation," Randolph Bolling; "The Great Iron Fields of the Lake Superior District," Robert B. Brinsmade; "Present Conditions of the Famous Comstock Mine, Nev.," Al. H. Martin; "The Great Iron Fields of the Lake Superior District," Robert B. Brinsmade; "Refrigeration as Practiced in Mining Operations," Samuel K. Patieson.

Photo-Era for December: "Art Appreciation in Europe and America," Alon Bement; "Two Great Discoveries in Aërial and Instantaneous Telephotography," John W. Turner; "Home Portraiture," Fedora E. D. Brown; "Landscape Photography in Winter," Phil M. Riley; "Enlargement by a Novel Method," James W. Russell.

Photo-Era for January: "Our Sixth Annual Contest," Wilfred A. French, Ph.D.; "Awards in the Photo-Era Annual Contest"; "The Coloring of Lantern-Slides," Edward Little Rogers; "Carbon Effects on P. O. P.," William Findlay; "Enlarged Negatives from Transparencies," Joseph Knaffl; "A New Lens Calculator," A. Lockett.

Physical Review for December: "The Ionization of Gases at High Pressures," Henry A. Erikson. "On the Supposed Excess of Negative Electrification Produced by Spraping," J. C. Pomeroy; "Some Physical Properties of Current Bearing Matter," V. Refractive Index, Paul R. Heyl; "The Crystallization of Undercooled Water," Boris Weinberg; "Distributed Capacity of Resistance Boxes," S. LeRoy Brown.

Physical Review for January: "On the Latent Heat of Fusion and the Specific Heat of Salts in the Solid and Liquid State," H. M. Goodwin and H. T. Kalmus; "An Experimental Study of Photo-active Cells with Fluorescent Electrolytes," Percy Hodge; "Some Phenomena of Persistence of Vision," Frank Allen; "The Rotary Power of Quartz at the Temperature of Liquid Air," F. A. Molby.

Popular Science Monthly for January: "The Career of Herbert Spencer," Lester F. Ward; "Lineaments of the Desert," Dr. Charles R. Keyes; "On the Therapeutic Action of Fermented Milk," Dr. C. A. Herter; "Poetry and Science in the Case of Charles Darwin," Edward Bradford Titchener; "A Biographical History of Botany at St. Louis," Dr. Perley Spaulding; "The Art of Bleaching and Dyeing as Applied to Food," E. H. S. Bailey; "Mr. Roosevelt's Opportunity as President of a University," Dickinson S. Miller; "Commercialism," John J. Stevenson; "Foreign Associates of National Societies," Edward C. Pickering; "The School and the Family," J. McKeen Cattell.

School World, London, for December: "Practical Introduction of Logarithms," G. H. Bryan. "The Educational Method of Disputations," Foster Watson; "Colour Photography," G. H. Wyatt; "Technical and Trade Schools," T. S. Usherwood; "A Course on Hygiene and Physical Training for Men," Sidney Skinner; "The Letters of Queen Victoria"; "The Educational Problem in Rural Schools"; "The Correlation of the Teaching of Mathematics and Science," Prof. J. Perry.

Scientific American Supplement for December 12: "Electrolytic Sheets and Tubes," Sherard Cowper-Coles; "Selenium Cells," R. A. L. Snyder; "Experiments on Water Resistance," Karl Wallin; "An Animal as an Engineering Structure," S. J. Meltzer.

Scientific American Supplement for December 19: "Radioactive Elements," A. T. Cameron; "Singing and Speaking Stones," Georg Rosenfeld; "Moving Water and Animals," Armand Billard; "Whitethroats," M. J. Niccoll; "An Animal as an Engineering Structure, II," S. J. Meltzer

Scientific American Supplement for January 9: "Utilizing Waste Wood." F. P. Veitch; "A 50,000-volt Transmission system," Frank C. Perkins; "Oils as Dust Preventives," Prevost Hubbard.

Technical World for January: "Who Owns the Earth?" Henry M. Hyde; "Keeping Paris Gowned in Green," E. A. Bingham and Wilfred Rocques; "Microbes to Fight Rats," F. A. A. Talbot; "When Reason Sleeps," Theodore M. Raulein, Ph.D.; "Search for a Car Fender," P. Harvey Middleton; "The Pecan—King of Nuts," Roy Crandall; "Pigeons as Picture-Makers," Dr. Alfred Gradenwitz; "Yawning Craters of the Moon," H. G. Hunting; "Hard Times Force Millennium," Samuel O. Dunn; "Torpedoes that Carry Guns," John Ray Smith, Jr.

SOUTHERN CALIFORNIA SCIENCE ASSOCIATION ORGANIZATION MEETING.

As the result of an inquiry sent out by Prof. W. A. Fiske, Occidental College, to science men in the schools of this vicinity regarding the formation of a Science Association in Southern California. The first meeting of those interested was held at 10 A. M., November 14, 1908, in the Committee Rooms of the Chamber of Commerce, Los Angeles.

The meeting was called to order by Prof. Fiske with an explanation of the reasons for the meeting, and Prof. Fiske having been appointed temporary chairman, and H. C. Clifton, Throop Institute, temporary secretary, discussion of the organization proceeded along the lines of the following outline of topics as suggested for consideration:

(1). Desirability of Science Association in Southern California by H. T. Clifton, and W. R. Bowker (Univ. So. Cal.) with an invitation from Prof. Bowker to hold meetings at U. S. C. at such times as should be convenient.

(2). Charter Membership.

Moved by W. K. Gaylord (Throop Institute), seconded by R. C. Daniels (L. A. High), and motion carried:

That those present to-day and those appearing at the next meeting shall constitute the charter membership of this Association.

(3). Committee on Constitution.

Moved by R. C. Daniels, seconded by W. K. Gaylord and carried:

That the Chairman appoint a committee of three on the Constitution. The suggestion was made that the Constitution be as short and concise as possible to cover the needs of the Association. Chair appointed:

C. S. Milliken, Throop Institute.

O. C. Albertson, Whittier High.

G. C. Bush, S. Pasadena High.

A. L. Cavanagh having been excused from serving.

(4). Time and place of meeting.

Discussion by Messrs. West (Occidental), Gaylord, Bowker, Fiske, Nye (U. S. C.), Clifton, Life. An invitation was presented from President Baer of Occidental College to hold the first meeting there.

The consensus of opinion was that there should be two meetings each year, that the meeting should be held on Saturdays at a time other than a vacation time and that for getting members together and to secure the services of a lecturer, a date convenient to the Institute week would be desirable. Upon motions duly seconded the first meeting was voted for a date in December and the invitation of Pres. Baer was accepted.

(5). Membership Dues.

Discussion by Messrs. Nye, A. C. Life (U. S. C.), Daniels, Clifton, Bowker. Moved by C. S. Milliken, seconded by W. K. Gaylord and duly carried:

That membership dues of the Association be one ($1.00) dollar per annum.

(6). Committee on Membership.

Discussion by Messrs. Albertson, Daniels, Nye, Tower, favored immediate appointment of committee and a general effort among all present to help the work of the committee. Motions for the decision of the number by the committee on the constitution, and for the immediate appointment by the chairman of a temporary committee were duly seconded and carried.

Appointed:

A. W. Tower, Polytechnic High, L. A.

S. H. Anderson, Occidental Academy.

C. E. Higbee, Excelsior Union High, Norwalk.

(7). Nominating Committee.

The chairman appointed:

Messrs. Bowker, Cavanagh (L. A. High), and Gaylord as a committee on nominations for the members of the Executive Committee and for the Officers of the Association.

(8). The Program—General or Sectional; Number of Sessions. Discussion by Messrs. Bush, Milliken, G. F. Cook (Occidental), Life, Daniels, Gaylord, Albertson, Monroe, F. H. Beals (Occidental).

A motion by A. C. Life that the first meetings be general, duly seconded, and the amendment to change the words "first meetings" to "regular meetings" offered by O. C. Albertson, duly seconded, upon a vote being taken, were lost.

A motion to have a general program at the first meeting was duly seconded and carried.

Upon a motion by A. W. Tower, duly seconded, it was voted to limit the length of the meeting to not longer than one day and to leave the consideration of the length of the other meetings to the Committee on the Constitution.

General.

Questions as to opening the membership list to ladies and including the teachers of Mathematics, already organized, were discussed. Upon motion of G. W. Monroe, duly seconded, it was voted to admit ladies to the organization.

Nominations.

The Nominating Committee made the following report:

For President, W. A. Fiske, Occidental.

Vice-President, W. R. Bowker, U. S. C.

Secretary-Treasurer, H. T. Clifton, Throop.

Members of the Executive Committee:

R. C. Daniels, L. A. High.

G. Walter Monroe, Whittier High.

Upon a vote being had they were declared elected.

The meeting then adjourned.

H. T. CLIFTON

ASSOCIATION OF TEACHERS OF MATHEMATICS IN THE MIDDLE STATES AND MARYLAND.

The eleventh meeting of the Association of Teachers of Mathematics in the Middle States and Maryland was held at Franklin and Marshall College, Lancaster, Pa., on November 28th.

After the address of welcome by President Starr, the following papers were read:

"Training versus Facts," William Henry Metzler, Syracuse University.

"Elementary Logic as a Basis for Plane Geometry," Eugene Randolph Smith, Polytechnic Preparatory School, Brooklyn, N. Y.

"The International Commission on the Teaching of Mathematics," David Eugene Smith, Teacher's College, New York City.

"Checks, Their Use and Abuse," William E. Breckenridge, Stuyvesant High School, New York City.

"Historical Mathematical Material from the East," Miss Bertha L. Broomell, Teachers' College, New York City.

The annual election of officers was held; the officers elected follow:

President, William Henry Maltbie, Woman's College, Baltimore, Md.

Vice-President, William E. Breckenridge, Stuyvesant High School, New York City.

Secretary, Eugene Randolph Smith, Polytechnic Preparatory School, Brooklyn, N. Y.

Treasurer, Emma Hazleton Carroll, High School for Girls, Philadelphia, Pa.

Members of the Council, William H. Metzler, Syracuse University; Susan C. Lodge, Philadelphia Collegiate Institute for Girls.

The council appointed ten delegates to the American Federation; a committee on publication composed of William H. Metzler, chairman, Eugene R. Smith, and Jonathan T. Rorer; and a committee on Mathematical work in continuation schools, having as chairman William E. Breckenridge.

The following amendment to the constitution was recommended by the council:

Paragraph I of Section VI to read, "The annual meeting shall be held at a time and place to be selected by the council."

The spring meeting of the Association will be held at Syracuse University on Easter Saturday.

EUGENE R. SMITH

MEETING OF THE ASSOCIATION OF OHIO TEACHERS OF MATHEMATICS AND SCIENCE.

The Association of Ohio Teachers of Mathematics and Science held its sixth annual meeting in Chemical Hall, Ohio State University, Columbus, Ohio, December 29-30, 1908.

At the sessions of the Mathematics Section, President B. F. Yanney, Mt. Union College, presided, the Science Section having for its chairman Vice-president Wm. Lloyd Evans, Ohio State University.

MATHEMATICS SECTION.

The first paper was presented by Mr. J. C. Boldt, Stivers Manual Training High School, Dayton, the title being, "The mathematical club in the high school; its use as a supplement to the work of recitation." Mr. Boldt outlined the character of the work done by the club at Dayton, and exhibited some excellent geometry models constructed by members of the club.

"On the nature of mathematical knowledge," was the subject of an interesting paper by Prof. F. E. Miller, Otterbein University. The discussion that followed was mainly upon the value of mathematics as a cultural study.

Prof. Paul Biefeld, Buchtel College, in his paper, "Should mathematics be taught as a basal science or as a tool of science?" stated that math-

ematics must be taught as a basal science in order that it may be used intelligently as a tool of science.

The last paper was by Mr. R. L. Short, Technical High School, Cleveland, the subject being, "Should the seventh to tenth grades be a unit in mathematics?" Mr. Short believed that arithmetic, algebra and geometry should be more closely united, and this could be accomplished by making the four grades a unit. An animated discussion followed.

SCIENCE SECTION.

In the paper, "Physics as a factor in forming character," Mr. Chas. M. Brunson, Central High School, Toledo, endeavored to show that Newton's Laws of Motion and the Law of Conservation of Energy were fundamental mental and moral laws as well as physical laws. He said that self-reliance is one of the virtues that can be inculcated by proper laboratory work. The discussion that followed centered upon the kind and amount of help that the teacher should give pupils in the laboratory.

The second paper, "The narrow path or the broad?" was presented by Mr. H. E. Newman, Walnut Hills High School, Cincinnati. He believed the duty of the teacher of science was to awaken if possible an abiding interest and a joy in science for the average high school graduate. The course in the high school should be made as broad and attractive as possible, the narrow and specialized paths being left until later.

A special feature of the meetings of the section was the exhibit of physical and chemical apparatus. Mr. Newman explained a very interesting color charts of the chemical elements that he had devised. Mr. R. O. Austin, Central High School, Columbus, and Mr. W. W. Parmenter, Steubenville High School, exhibited several pieces of home-made physical apparatus. Prof. Evans explained a very useful colored-pin-device for the assignment of pupils and sections in the laboratory.

Prof. Fred J. Hillig, St. John's College, Toledo, gave a demonstration with his wave-motion apparatus and illustrated a number of its many uses. Mr. Chas. E. Albright, North High School, Columbus, performed a number of experiments with an apparatus of his own design for the verification of Hookes Law.

The lecture on, "The purification of drinking water," by Prof. C. W. Foulk, Ohio State University, was of unusual interest. The lecture was illustrated by lantern slides and experiments and especial attention was given to the method of purification and softening at the new plant at Columbus. Timely suggestions regarding household methods were given.

The afternoon of the last day of the meeting was devoted entirely to an excursion to the Columbus Filtration Plant. The trip proved so interesting and profitable that many expressed the desire that an excursion be a regular feature of the meeting.

The Association voted to affiliate with the American Federation of Teachers of Mathematics and the Natural Sciences. The two delegates to which the Association is entitled will be selected by the new Council, which is as follows:

President, Miss Stella S. Wilson, Central High School, Columbus.

Vice-president, Prof. G. N. Armstrong, Ohio Wesleyan University, Delaware.

Secretary-Treasurer, Mr. Chas. T. Prose, High School, Zanesville.

RALPH W. BUCK

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

PHYSICS SECTION, NOV. 26, 1908.

The Annual Meeting of the Physics Section of the Central Association of Science and Mathematics Teachers was called to order by Chairman Goodell, in the Englewood High School at 1:30 p. m., with about 60 members in attendance.

After a few introductory remarks by the Chairman, the first paper of the meeting was presented by Prof. R. A. Millikan, of Chicago University, on The Correlation of Physics in the University and the Secondary School.

As the original MS. has not yet come into the hands of the Secretary, only one or two salient points can be given now.

The author believes that too much time has been given to purely quantitative work, and that some of this time could be better given to other subjects. Further, he feels that the secondary school man, who does the work, and is fully in touch with the student, is better able to judge what the student can fairly be expected to accomplish.

His views would lead him to believe that so soon as the secondary school men can define and agree upon a satisfactory "unit in Physics" that he would advocate its immediate acceptance by the university, as its basis of required work, for entrance.

The paper was most welcome as an exponent of the view that the secondary schools have ample means of judging what their students may be asked to accomplish, and are better equipped for deciding this matter than are the university men, most of whom do not come into personal contact with this grade of instruction.

The discussion which followed was interesting and profitable. It was begun by Mr. A. A. Upham, of the Whitewater State Normal School, who emphasized the fact that excessive attention had in the past been given to quantitative work, and that the concrete, practical and interesting phases of the subject had been too much neglected.

As in their boyhood, some of our greatest scientists had not been trained in quantitative measurements, such for instance as Tyndall and Huxley, the speaker felt that too much value had been set upon this portion of the subject. Like Prof. Millikan, he felt that the instruction should be planned mainly with reference to the larger number of boys and girls, who did not go to college, rather than with special reference to the requirements for admission to college.

Probably too much weight has been given in the past to the suggestions of the universities by the secondary schools, simply because these schools wished a place on the "accredited list of schools".

The discussion was continued by Prof. Woodhull, of the Teachers' College, of Columbia University, who said that he felt that much of the gap between the university and the secondary school had grown out of the fact that the college antedated the secondary school in point of time, and that the colleges had therefore resisted with more or less success the efforts of the secondary schools to "bring them down to the level of the high schools".

Successful efforts to bring the college and the secondary teacher into working contact are recent (not more than 4 or 5 years), but they promise

much in the way of promoting better understanding of the work and its limitations.

Examinations are a poor means of testing the work done and of measuring school progress. He was confident that in a few years the entrance examination would be a thing of the past, and entrance would be granted to all pupils who were duly accredited by good schools, at all colleges and universities.

Ignorance on the part of the college man has been the chief cause of his inability to judge what should be done in the secondary school. Visitation, repeated, frequent, judicious, is necessary to secure due acquaintance for the college man with the secondary school and its work.

Further, in too many cases, the college has not properly prepared the young teachers. In the experience of the speaker a radical change in the attitude of the instructor has taken place, after an experience of a few years, that has made his work much more rational, and much more adapted to the student of the secondary school.

Our chief difficulties lie not with our students, but with our teaching. Probably our best work is to be found in the small high schools, with but few teachers, on account of the close personal contact between teacher and pupil, which is there possible.

The secondary teacher has shown too little independence of the college, though this is fast disappearing.

The next paper was read by Prof. Henry Crew, of Northwestern University, on Force and Torque, with some experimental illustrations.

After calling attention to the difficulty found by many in defining the term force, he reminded us of Galileo's experiments showing that force produces acceleration, and of his suggestion that acceleration is due to something, we know not what, that he suggests should be called force. In some such sense, the word force has always been employed by the physicist.

The definition of force was completed and perfected when Hughens and Newton discovered the variability of gravity. Newton appreciated the importance of this discovery, and assigned the name of mass to that factor of weight, which does not vary, when the acceleration of gravity changes—which remains constant, no matter where a body is placed.

With Newton's Third Law it became clear that in all actions, whether accelerations or mere stresses, two equal and opposite forces are always involved.

In the study of phenomena, they are said to be explained only when classed with other phenomena which we already understand, so that analogy is a powerful means of explanation, too seldom employed.

Three fundamental phenomena were then taken up and discussed with full illustrations, the gyroscope, and its behavior, when one end of the axle of the rotating wheel is left unsupported; Schlick's ship steadying device, now being tested in the German navy, as a means of lessening the excessive rolling of the small torpedo boats; and Brennan's mono-rail car, suggested as a means of securing simpler and more effective construction of our elevated railroads.

The experiments presented were completely successful and served admirably to illustrate and explain the meaning of the speaker in his excellent paper.

Mr. H. C. Krenerick, of Milwaukee, then presented a paper, with lantern illustrations, showing the equipment of the new laboratory in the North Division High School, at Milwaukee. Much interest was shown in the description of the facilities enjoyed in this up-to-date school.

Mr. Charles H. Slater, of St. Louis, then presented a new Model Electric Motor, so planned as to permit detailed study of the working of the different parts, which has been worked out in the St. Louis schools, and is soon to be put on the market by the Central Scientific Co.

He also called attention to the use of the capillary tube, containing air, kept dry by sulphuric acid, with a mercury thread, for use in measuring the coefficient of cubical expansion of air.

The most important portion of this talk dealt with the development of the "discussion" at the end of the experiment, this consisting of a carefully prepared series of questions, designed to help the student to a full and complete understanding of the work done in the laboratory.

The meeting then adjourned until 8:00 p. m., when the Section resumed its sessions, after the Annual Dinner had taken place.

The first paper presented in the evening was by Mr. H. L. Terry, of Wisconsin, on "The Present Status of the New Movement in the Teaching of Physics".

The speaker began with a brief summary of the history of the teaching of physics in the high school, beginning with a text like Steele's Fourteen Weeks, passing through an extreme form of purely laboratory methods, and on to the more recent and more rational methods of presentation, which combine in the best way the lecture room and the laboratory, so as to familiarize the student with what is best in each.

The college specialist has too largely dominated the teaching of physics in the past, and the new movement aims to return to former methods so far as may be needed to make our work better adapted to make our students acquainted with physical phenomena and their causes.

So great emphasis has been put upon physics as being an exact science, and hence requiring purely quantitative treatment, that undue emphasis has been given to complex apparatus, to exact measurements and imperfectly understood formulae, and that there has resulted a corresponding lack of emphasis upon underlying laws and principles and their applications.

Actual questioning of the student has in many cases revealed his ignorance of the work and of the real meaning of the formulae in use, while the work itself was in many cases better suited for the college than for the secondary student.

Unless reforms are brought about in our methods of presentation, physics is likely to become a study valued only by future engineering students, and as one high school principal expressed himself, merely "a study in applied mathematics".

Since in most cases, college work is not directly based upon the work of the high school, why should the college attempt to dictate the work of the high school? In mathematics and in the languages, this does not apply, but in science it holds, and certainly the high school teacher should be permitted freedom to conduct his own work in his own way.

Several papers were then presented on the Fundamentals of Physics. Mechanics was taken up by Prof. G. M. Wilcox, of Armour. His paper

contained an admirable description of a new experiment designed to prove that acceleration is proportional to the accelerating force. A piece of plate glass about 3′ x 6″ was mounted on rollers, and given just enough slope so that the weight of the pan attached to the upper end by a cord passing over a pulley would keep it in slow motion, when once started. If small weights previously placed on the glass are now transferred to the pan, it may easily be shown that the acceleration is proportional to the accelerating force, especially if an electrically operated fork is allowed to trace its curve on the smoked surface of the glass.

Fundamentals in Sound was then presented by Prof. D. C. Miller, of the Case School of Applied Science, at Cleveland. The more important topics, which should be taken up within two or three weeks are:—The causes of hearing, wave motion, nature of sound, reflection wave motion, noise and musical tones, origin of sound waves, three characteristics of sounds (pitch, intensity and tone quality), musical scale, resonance interference, laws of strings, all of which should meet with full illustration either in the lecture room or in the laboratory, preferably the former.

Fundamentals in Heat was then presented by Prof. K. E. Guthe, of the University of Iowa. The chief topics suggested were:—The meaning of temperature and heat, the fact that heat can be measured and the methods of measurement; the principle of the conservation of energy, and the principle that in natural phenomena, heat flows from points at higher temperatures to those at lower ones. To make these ideas well understood, and make it more enjoyable, ample illustrative material should be selected by the teacher.

Fundamentals in Electricity was then presented by Prof. John F. Woodhull, of Teachers College, Columbia University, the cardinal idea of the speaker being that of making the instruction strictly practical. Local conditions must alter methods of instruction. It is assumed here that direct current at 110 volts is available. A rheostat which enables us to obtain from 1 to 15 amperes is desirable, so that demonstrations may be made, using throughout the volt-meter, the ammeter, and the wattmeter, so that all results may be put into concrete form by the student. Electrical measurements should be taught incidentally, but thoroughly, as may well be done, with the proper instruments constantly before the student.

Next, put before the student some of the devices using the current to produce heat, such as the laundry iron, the cooking utensils, etc., and have the student determine the cost of operation. Next, let the student study the arc lamp, the incandescent and other forms, always using the measuring instruments in his study. Have a large electro-magnet wound for 110 volt current, so that it may be used for actual study of the magnetic field, both in magnetizing iron brought into its vicinity, and by making a loop of wire cut the lines of force and generate a current to be measured in the usual manner.

When the student has mastered these, let him take up the D. C. dynamo, the A. C. dynamo, the magneto, and the uses of the electro-magnet in the telegraph, the telephone, the bell, etc.

Fundamentals in Light were then presented by Mr. Geo. B. Twiss, of Columbus, Ohio, but as no copy of the paper has yet reached the secretary, mention of it is necessarily limited.

The annual election of officers then took place, resulting as follows: Chairman, C. H. Perrine, Chicago, Ill.; Vice-chairman, R. F. Ratcliffe, Danville, Ill.; Secretary, V. D. Hawkins, Joliet, Ill.

Adjourned.

REPORT OF THE MEETING OF THE EARTH SCIENCE SECTION, C. A. S. and M. T.

The eighth annual meeting of Earth Science Section of the Central Association of Science and Mathematics Teachers, was held at the Englewood, Chicago, High School, November 27 and 28, 1908.

The meeting was called to order by the chairman, Mr. James H. Smith, of the Austin, Chicago, High School, there being about fifty persons present.

The chairman appointed a nominating committee consisting of Dr. C. E. Peet, of Lewis Institute; Mrs. J. P. Cooke, of the Chicago Normal School, and Mr. C. E. Spicer, of Joliet, Illinois.

The first paper was read by Prof. Mark Jefferson, of the State Normal College, Ypsilanti, Michigan, on "Facts and Principles of Meteorology that are Essential to Physiography". This paper appears printed in full in the January number of this journal.

The second paper was read by Prof. R. D. Salisbury, of the University of Chicago, on the subject "Fundamental Topics in a Physiographic Study of the Land". In the opinion of Prof. Salisbury high school pupils should get certain big ideas and should also do some intensive work on a few subjects. One of the first big facts to be taught about the lithosphere is that about one-third of its surface is about three miles above the other two-thirds. The origin of continents should be discussed whether geologists know the cause or not. Land areas should be roughly divided into plains, plateaus and mountains. Clear ideas of these three forms are most essential, yet the pupil must understand that exact definitions and sharp lines of demarcations are not always possible. Pupils should have a broad view of the work of gradational forces and should understand clearly the relation of diastrophism to gradation.

As subjects for intensive work pupils may profitably study the manner in which gradational forces operate. Prof. Salisbury here outlined in some detail the manner in which river valleys become wider and deeper and longer. The development of a river system upon a plain with the consequent disappearance of swamps and lakes and the development of hills was also sketched. No teacher of physical geography can afford to be without Prof. Salisbury's new book. It is published by Henry Holt & Co.

Methods of Teaching by which Fundamental Parts of Physiography may be Emphasized was discussed by Ralph E. Blount, of the Waller High School, Chicago, and George A. Barker, Normal, Illinois.

Mr. Blount's paper contained a number of excellent points based on his experience in teaching land forms. Mr. Blount uses the sand tray to show processes and to test the pupil's knowledge. He finds pupils more ready to perform experiments than to make observations. His experience has shown that for many reasons a wet laboratory is better than observation work in the field. In experimental work the pupil is working and in observational work he is merely looking on.

The best rain making apparatus yet tried is a common spraying nozzle used in applying whitewash. For delta making fine and coarse sand

mixed is found better than sand and clay, as the water remains clear enough to allow the pupils to see what is going on beneath the surface of the water.

A paper on the Practical Value of Geology was given by Prof. U. S. Grant, Northwestern University, Evanston, Illinois.

Prof. Wm. H. Hobbs, of the University of Michigan, gave a talk on the subject, "Instruction in the Use of Topographic Maps". An ingenious apparatus was shown by which students can measure the altitude of points on a model, these altitudes to be used in constructing a topographic map of the region shown in the model.

The officers elected for next year are: President, Miss Marion Weller, State Normal, De Kalb, Ill.; Vice-president, W. M. Gregory, Central High School, Cleveland, Ohio; Secretary, Mr. Harry Gillett, School of Education, University of Chicago. W. S. McGee.

MEETING OF THE CHEMISTRY SECTION

The first session of the Chemistry Section of the C. A. S. & M. T. was held in the chemistry lecture room of the Englewood High School at 2 o'clock Friday afternoon. It was well attended and much enthusiasm was manifest. The first topic, "How May Elementary Chemistry Be Made More Efficient?" was presented by E. B. Hutchins, Jr., Professor of Chemistry, Carroll College, Waukesha, Wis. He emphasized the importance of making chemistry a thought study and not one for the cultivation of memory alone; that the student should gain the power to do things rather than simply to acquire facts. He also emphasized the importance of studying the chemistry of everyday life and took the view that we should attempt less of the theoretical: further, that it is important to give more personal or individual attention to each student than we are doing at present.

A general discussion followed the reading of the paper.

Mr. J. L. Welter, of the department of chemistry of the Wilkesbarre, Pa. High School, read the next paper, subject, "Difficulties to be met in Secondary School Chemistry". The subject was closely akin to the preceding, but the method of treatment was entirely different and the one supplemented the other, as if so intended. Five points were considered:

a. Applied Chemistry rather than College Requirements.
b. Differentiation along different lines.
c. Too much in our text-books.
d. Drudgery of laboratory housekeeping.
e. More time needed in laboratory.

These points were discussed at length at the close of Mr. Welter's talk.

After the discussion the committee on "Fundamentals in Secondary School Chemistry" made a preliminary report. To carry on and complete the work thus begun, Geo. A. Abbott, of Indianapolis; Dr. A. L. Smith, of the Englewood High School, Chicago, and F. T. Jones, of Cleveland, were appointed a committee with instructions to make full report at the next meeting.

Saturday morning was given up to a round table. The two topics, "Chemical Theory, What and How", and "Practical High School Chemistry" were introduced by Geo. A. Abbott, of Indianapolis, and C. M.

Wirick, of the Lane Technical School, Chicago, respectively. A large number of the teachers present entered heartily into the discussions and much in the way of practical experiment was introduced.

Altogether the meeting was a very enthusiastic one, was largely attended and full of profit to every one. F. N. PETERS.

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

[ABSTRACTED FROM PROCEEDINGS.]

The fifty-first meeting of this association was held Friday evening and Saturday, October 23 and 24, at Boston University. The Friday evening address was given by Professor Robert A. Millikan, of the University of Chicago, on "The Relation of High School and College Physics". Following the address a general discussion took place upon the influence which the colleges exert in forming the secondary school curricula. Professor Hall, of Harvard University, spoke in favor of the position which this institution has taken in requiring laboratory exercises for entrance, to be taken from a prescribed list. Mr. Black, of the Roxbury Latin School, Boston, spoke of the method adopted by the College Entrance Board of submitting its examination questions to a committee of eight secondary school men for criticism before publishing the list. At the close of the session a vote of thanks was extended to Professor Millikan for his excellent address.

The Saturday morning session was called to order at 10:15 by President Fred R. Miller. The secretary's printed report of the last meeting was presented and accepted. The report of the treasurer was also received and accepted.

Mr. Merrill presented an interesting and instructive report from the committee on magazine literature covering the period from May to September, 1908, inclusive. Mr. Chittenden then reported for the Committee on Current Events in Physics. Mr. Hall, from the Committee on New Apparatus, exhibited a small plug resistance box with a 100-ohm coil in addition to those usually found in boxes for secondary school work. Mr. Hall also showed a new type of Wheatstone Bridge, the contact point being carried on a round rod so arranged that the contact point is kept off from the wires when not in use. Two wires, which carry the current, are placed one on each side of the rod. By this arrangement the contact point may be pressed down on either wire, and if the wires show different readings for a given position, an average is taken.

Mr. Parish showed a device for illustrating the principle of the parallelogram of forces. He also exhibited a wooden model of a cubical expansion apparatus. Mr. Cowen showed three pieces of apparatus—a dipping needle, a laboratory balance with counterpart, and a Gilley motor.

Under the head of new business several new members were elected to membership in the association.

Mr. Black presented a review of Crew's New General Physics and Mr. Jackson gave a review of Duff's Text-Book of Physics. Mr. Peterson discussed Turner and Heney's Loose Sheet Notebook.

Mr. Lyons, of the Institute of Technology, showed a new mechanical rectifier. This particular device gives excellent results under different conditions; any voltage from 0 to 120 and any current from 0 to 70 amperes may be obtained.

Professor Norton A. Kent, of Boston University, then addressed the meeting on "Variability of Wave Lengths of the Spectrum Lines". After explaining the grating spectroscope in general, he described the particular apparatus which he used in his investigations. Strips of photographic plates were exposed and a trifle exposure was made on each in such a way that an arc spectrum occupied the center of the plate with the spark spectrum above and below it. Apparatus used for producing the spark was shown, also numerous lantern slides made from the original plates were shown.

The Symposium on Useful Laboratory Manipulations followed the address of Professor Kent. Messrs. Boylston, Greenlaw, Hyde, Tilley, Rice and Palmer presenting new methods. Professor Hall described an apparatus to show the friction of air in tubes; he also demonstrated a new method for measuring surface tension.

At the close of the program a vote of thanks was extended to Professor Kent for his address, and to Boston University for the use of the laboratories.

C. H. S.

MATHEMATICAL CONFERENCE.

H. E. SLAUGHT.

University of Chicago.

The Annual Conference in Mathematics at the University of Chicago, November 16, 1908, was attended by about forty teachers and much interest was developed in the discussion of the improvement of the teaching of Geometry. The discussion was opened by Principal H. W. Hurt, of Oskaloosa, Iowa, and carried on with vigor by numerous volunteers from various representative schools, including the University of Chicago High School, the Manual Training High School of Indianapolis, Indiana, and the Evanston High School. The chief lines of discussion are indicated by the following questions, which were proposed in connection with the call for the conference:

IMPROVEMENT IN THE TEACHING OF GEOMETRY.

1. Is Geometry as now taught sufficiently in touch with the world in which the pupil lives?
2. Is the pure logic of Geometry as currently given adapted to the average second-year high-school pupil?
3. Should the time-worn dictum "Geometry for mental discipline" be the sole criterion?
4. What suggestions from your own experience will you propose for improving the Geometry situation?

Discussion opened with a brief address by Principal H. W. Hurt, Oskaloosa, Iowa.

There seems to be a widespread feeling among the teachers of geometry throughout the Middle West that the schools are not doing their full duty in respect to this subject. It is very generally believed that too much formal logic and too many unrelated and abstract propositions are forced upon the beginning pupil and not enough opportunity is given for concrete illustrations and everyday uses of geometry. It is interesting to note that this same question came up at the Thanksgiving meeting of the Central Association of Science and Mathematics Teachers, and that a committee of this association has been appointed to collect material for concrete applications of Geometry.

ASSOCIATION OF MATHEMATICS TEACHERS IN NEW ENGLAND.

The sixth annual meeting of this association was held at the High School in Charleston, Saturday, December 5, 1908. The first part of the morning session was devoted to business, after which the question "Loci Problems in Geometry" was discussed from the point of view of the college, by Professor E. B. Wilson, of the Institute of Technology, followed by a paper from the point of view of the secondary school by Ernest G. Hapgood, of the Girls' Latin School, Boston. The general discussion which followed was participated in by William Fuller, of Mechanic Arts High School, Boston, and Mary F. Gould, Roxbury High School.

Luncheon was served from 1 to 2 p. m. At 2 o'clock the association was called to order, when the following officers were elected:

President, Charles A. Hobbs, Watertown, Mass.; Vice-president, William R. Ranson, Tufts College; Secretary, George W. Evens, Charleston, Mass., High School; Treasurer, William B. Carpenter, Mechanic Arts High School, Boston; Members of Council—Professor Dana P. Bartlett, Massachusetts Institute of Technology; Gertrude E. Bigelow, Boston Normal School; William T. Campbell, Boston Latin School; Edward V. Huntington, Harvard University; Miss Parnell S. Murray, Girls' High School, Boston, and Harry Wheeler, English High School, Worcester.

After this election, Professor Julian L. Coolidge, of Harvard University, read a paper on "What is a Ratio"; following this was an interesting feature of the meeting, "The Question Box", in charge of George W. Evens, of Charleston High School. The answer to the questions brought out spirited discussions. This meeting proved to be one of the most helpful in the history of the organization. C. H. S.

PERSONALS.

Mr. W. C. Hawthorne, who for a number of years was Dean of the Preparatory School Association Institute, Chicago, has recently been appointed professor of chemistry in the College of Physicians and Surgeons of the University of Illinois.

Mr. J. Harry Clo, a frequent contributor to this Journal, has resigned his position as instructor in physics at the University of Virginia, Charlottsville, and is now working for his doctor's degree at the University of Chicago.

TO MATHEMATICS TEACHERS.

The committee of the mathematics section of the Central Association of Science and Mathematics Teachers on the Unifying of Secondary Mathematics, wishes to obtain the names of all teachers in the United States who are making experiments along this line. Many teachers are securing good results from careful experiments either in the use of problems, or of laboratory methods, while some are actually connecting mathematics with physics or with the real life and interests of the pupils. Will not all teachers who are doing something in this matter send their own names, and the names of other teachers who are trying out these methods to W. W. Hart, Shortridge High School, Indianapolis, Ind.?

Important announcement. Good news to all students and lovers of nature and to all interested in education. The establishment of Arcadia on unique lines as a great nature study institution. (Through the aid of a philanthropist whose name is withheld by request.)

Arcadia is to be a "village" of portable buildings devoted to various phases of natural science. The buildings are to be arranged in the form of a court covering more than a half acre of ground. There is to be an astronomical observatory, "Home" of The Agassiz Association, biological laboratories, vivaria, aquaria, Clearing House (for circulating specimens), pet houses, insectary, photograph gallery, experimental rooms, offices, lecture hall, etc. Within the court made by the surrounding buildings are to be a garden and plant beds for experimental purposes.

In brief, it is to be an epitome of the essential features of zoölogical park, biological laboratories and experimental horticultural grounds.

If the experiment proves a success upon two years' trial, it is promised that the entire equipment will be rebuilt in larger fireproof buildings (with more extended equipments for study and experiment). The tests of success are the coöperation and interest of naturalists of all ages in all parts of the world. Full particulars in the January number of "The Guide to Nature," Stamford, Connecticut. Single number, 15c. Subscription for one year, $1.50.

EDWARD F. BIGELOW, Director of Arcadia.

Stamford, Conn.

BOOKS RECEIVED.

College Entrance Examination Board, Examination Questions, for June 15-20, 1908, 8vo, half cloth, 127 pages. Mailing price, 70 cents. Ginn & Co., Chicago.

Graded Exercises in Phonography, by William L. Anderson, Dorchester High School, Boston, 8vo, paper, 137 pages. Mailing price, 55 cents. Ginn & Co., Boston.

Outline of Practical Geography by Grades, by J. Russell Smith, University of Pennsylvania. Introduction price, 25 cents. Per 100, $20. William B. Harrison, Publisher, 15 Broadway, New York City.

Elementary Forge Practice, by John L. Bacon, Lewis Institute, Chicago, 12mo, X+279 pages, 335 figures. Cloth, $1.50. John Wiley & Sons, New York.

BOOK REVIEWS.

College Entrance Examination Board, Examination Questions for June 15-20, 1908. 8vo, half cloth, 127 pages. Mailing price, 70 cents. Ginn & Co., Chicago.

To the person, teacher or candidate, who wishes to keep in touch with the work which the College Entrance Board is doing, to become familiar with the nature of the work covered in these examinations, this compilation will be exceedingly helpful. They form the basis of a splendid review in any particular subject.

The book contains in addition to questions, a list of the examiners who prepared the questions in each subject, and of the readers who graded the answer papers in each subject. It also contains a short description of the organization and plans of the Board. C. H. S.

Analytic Geometry, by E. W. Nichols, Professor of Mathematics in the Virginia Military Institute. Revised edition. $1.25. Pp. XI+282. D. C. Heath & Co. 1908.

In this book the usual topics and principles of analytic geometry are presented so simply and clearly that they can be grasped readily by the student. As the first chapters are not overloaded with extraneous matter the circle is reached on page sixty; hence there is sufficient time for the student to become well acquainted with the parabola, ellipse, hyperbola, and a few higher curves, and also to get a working knowledge of solid analytic geometry. This book can be recommended to teachers who wish to follow traditional lines. There is no attempt, even in the lists of problems, to connect the subject with anything the student has done or will do. The tangent of each curve is derived separately by the secant method, though it would seem that we have reached a stage of development where every author would see the advantages of the general method of the calculus. This edition is put in the pocket form, which has proved popular with the newer mathematical books published by this company. H. E. C.

Graded Exercises in Phonography, by William Lincoln Anderson, head of the commercial department, Dorchester High School, Boston, Massachusetts. Ginn & Co., Boston.

The best method of learning to write shorthand is to write shorthand. This rule need not be considered too succinct, neither too general, provided all proper conditions are fulfilled. The phonography book with the above caption seems to be designed by its author to meet all the conditions required for a rapid mastery of stenographic writing.

A large number of very practical words and phrases are in this book, printed in columns opposite blank spaces in which the student may write the corresponding stenograph. This feature alone is worthy of high commendation; almost any student will exercise greater care in his writing when such an arrangement of words and phrases is provided than when doing his exercises in an ordinary blank book. The use of the book will develop habits of carefulness; save time for both teacher and pupil, and provide an advantageous method of examining the pupil's work. H. V. H.

Elementary Principles of Agriculture, by A. M. Ferguson and L. L. Lewis. 304 pages and 179 figures. Published by the Ferguson Publishing Company, Sherman, Texas.

The present unprecedented interest in agricultural pursuits has stimulated the production of numerous text-books upon agriculture for public school use. Some of these have been written by people whose chief qualification for the task has been their realization of the need. A book that evidences not only an appreciation of the need, but a pretty good understanding of the volume of usable science knowledge, is Elementary Principles of Agriculture.

The work planned in this book attacks the problem of agricultural teaching from the point of view of a study of plants—indeed the first part of the book is not unlike the beginning of some of our best text-books upon botany. It is difficult to understand just how the topic "The Green 'Pond Scums,'" and illustrations of Karyokinetic division of cells need the introduced in the beginning of a text-book on agriculture. The practical work

upon germination of seedlings, the relation of plants to the soils, the essential plant foods, the nature of the work and growth of plants, the productivity of various soils seem to constitute a logical starting point for such a text. Some of the purely botanical chapters as those upon "Relations of Plants above Ground" and "The Office of Flowers" are not sufficiently fully treated to give adequate botanical understanding of the situations at hand, and are not closely enough related to applied botany to give them full meaning in agriculture. Notwithstanding these deficiencies these chapters offer one of the nearest approaches we have seen to an adequate presentation of applied botany in an agricultural text.

The book treats of the various agricultural interests—farm plants and animals, their proper judging, selection, cultivation, and the diseases that affect them. A valuable chapter is added upon Farm Machinery, by Professor J. B. Davidson, of the Iowa State Agricultural College. Altogether the book represents one of the best attempts to reduce agricultural knowledge to an organization usable for elementary education. O. W. C.

Bacteria in Relation to Country Life, by Jacob G. Lipman, Ph. D., Soil Chemist and Bacteriologist for the New Jersey Agricultural Experiment Station and Associate Professor of Agriculture in Rutgers College. Published by the Macmillan Company, New York, 1908. 20+486 pages, illustrated. Price, $1.50.

There is today an increasing demand that the teaching of the classroom and the work of the laboratory shall have a close connection with the life of the community. The author of this book has recognized this demand and has given to the public a volume demonstrating a very vital connection between the bacteriological laboratory and the activities of everyday life. He seems to have the happy faculty of expressing the knowledge possessed by the bacteriologist in language intelligible to the ordinary reader and yet in terms of scientific accuracy. Bacteria are shown to have so intimate a connection with the numerous problems of modern life that the reader is impressed with the necessity of knowing much of their nature and work in order to intelligently perform the tasks of daily life.

The book will doubtless prove a most serviceable one to all students of agriculture, but it should also find a place in the library of all teachers who wish to help their pupils to live sane, healthful lives.

There is a short history of the rise and development of the science of bacteriology, followed by a simple description of the structure of these organisms and an investigation of conditions under which they develop. There follows a good discussion in non-technical language of the bacteria in the air and water with their relation to disease, including modern methods employed for the purification of water supplies. How bacteria are used in disposing of sewage is explained and also how they affect the fertilizing value of barnyard manure. This naturally leads to the subject of the various soil bacteria and their relation to the fertility of the soil. This topic receives the extended treatment it deserves, while somewhat less space is devoted to bacteria in relation to milk and its products and to the preservation of food.

The book is logical in its arrangement, simple and clear in its style, carefully indexed, and well printed with helpful illustrations. GEO. D. FULLER.